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September 2002

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Information Resources on Induced Molting in Chickens

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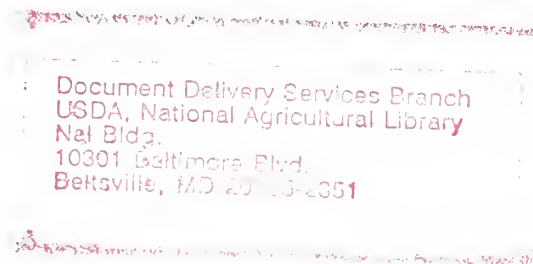
Information Resources on Induced Molting in Chickens 1902 – 2002

AWIC Resource Series # 14

September 2002

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The Animal Welfare Information Center also gratefully acknowledges **BIOSIS**, a leading not-for-profit organization whose mission is to foster the growth, communication, and use of biological knowledge for the common good. More information on BIOSIS is available at <http://www.biosis.org>.

How to Use This Document

This publication is a comprehensive bibliography containing citations that are arranged alphabetically according to the last name of the primary author. Each entry also contains abstracts, if available, descriptors, and the NAL call number if the resource is available at NAL. If the full-text of the article/resource is available on the WWW, the URL is provided. At the end of some subsections are listings of World Wide Web sites that will provide additional information on the topic. Web addresses are current as of August 1, 2002.

This document is divided into 3 sections: (1) Cooperative State Research, Education, and Extension Service (CSREES) Current Research Information System Reports (CRIS), (2) a comprehensive review of the literature available in electronic databases, and (3) additional records from the National Agricultural Library Electronic Catalog.

Cooperative State Research, Education, and Extension Service (CSREES) Current Research Information System (CRIS) Reports

Records in this section were retrieved from the Current Research Information System maintained by the Cooperative State Research, Education, and Extension Service. CRIS is the U.S. Department of Agriculture's (USDA) documentation and reporting system for ongoing and recently completed research projects in agriculture, food and nutrition, and forestry. Projects are conducted or sponsored by USDA research agencies, state agricultural experiment stations, the state land-grant university system, other cooperating state institutions, and participants in a number of USDA research grant programs. It is available on the web at <http://cris.csrees.usda.gov/>

Review of the Literature

Records in this section were retrieved from the Agricola, Medline, CAB International, AGRIS, BIOSIS, and Japanese Science and Technology databases. A search of the CRISP database, that is similar to CRIS, but maintained by the U.S. Public Health Service, revealed no funded projects relating to induced molting and its effects on Salmonella. Some sections also have relevant websites that will provide additional material not found in journals or databases. **Please note that citations with a copyright notice are protected by U.S. and/or international copyright laws and are used by special permission.**

National Agricultural Library Electronic Catalog

Generally, this resource is closely related to Agricola. However, some relevant materials not appearing in the Agricola database were retrieved and included here. Materials are arranged chronologically.

National Agricultural Library Document Delivery Information

The information contained here provides directions on how to obtain copies of articles mentioned in the bibliography from the National Agricultural Library. However, **you are encouraged to consult local resources first** before contacting the National Agricultural Library.

**Cooperative State Research,
Education, and Extension Service
(CSREES) Reports**

Termination Year 2006

ACCESSION NO: 0152013 SUBFILE: CRIS
PROJ NO: NC06184 AGENCY: CSREES NC.
PROJ TYPE: HATCH PROJ STATUS: REVISED
START: 01 OCT 2001 TERM: 30 SEP 2006 FY: 2001

INVESTIGATOR: ANDERSON, K. E.

PERFORMING INSTITUTION:
POULTRY SCIENCE
NORTH CAROLINA STATE UNIV
RALEIGH, NORTH CAROLINA 27695

MAXIMIZATION OF LAYING HEN PERFORMANCE, ECONOMIC RETURN, AND EGG QUALITY

OBJECTIVES: Determine methods to optimize the productive potential, economic return, and egg quality of commercial strains of egg-type chickens by manipulation of pullet and layer nutrition, physical environment, husbandry practices, induced molt programs and shell egg processing factors. 1) Determine the relationship between body size and age at sexual maturity on subsequent layer performance and egg mass produced. 2) Determine the effects and interactions of strain, house type, density, husbandry practices, and layer nutrition on production and economics. 3) Determine the effects and interactions of induced molt programs on production, behavior, and economics. 4) Determine the effects of current egg processing technology on the physical quality and microbiological safety of shell eggs. 5) Examine alternative manure disposal systems.

APPROACH: Commercial strains of white and brown egg-type chickens and the eggs that they produce will be utilized. Pullets will be reared in environmental control housing with various combinations of nutritional or management programs which affect the productivity of the layers at the Poultry Research Unit of the Piedmont Research Station at Salisbury, NC. The factors could include: light programs, dietary regimen, body weight program, molt techniques, husbandry practices, environment control programs, and egg handling programs. Pullets and layers will be managed as close to commercial industry standards as possible except when deviations are needed to accomplish the research objectives. Pullet body weights, feed consumption and mortality as well as hen feed consumption, egg production, egg quality and livability data will be collected on each flock. Productivity will be defined by various measurements of body weight, skeletal structure, feed consumption, immune competence, physiological health, and egg production criteria. The welfare status will be defined by the behavioral profile and hormonal response of the birds. Egg quality will be defined by the USDA egg quality standards, physical shell and membrane measurements, and through microbiological testing of the shell and contents. The potential of poultry manure as an organic fuel source will be evaluated from commercial sources and based upon governmental standards for emissions. The general experimental design will be a factorial arrangement which will

allow for examination of multiple factors simultaneously.

NON-TECHNICAL SUMMARY: NA

PROGRESS: 2000/10 TO 2001/09

The Pullet Rearing report for the 34th North Carolina Layer performance and management test indicates that there is divergence in growth parameters of the different commercial white egg layer strains available. The first cycle report is under preparation and a significant comparison of molt programs has been completed. The second full trial using the avian cancer model has been initiated. The current study has been established to evaluate a new therapeutic application of a cancer treatment drug. This study will evaluate the drug's cancer inhibitory effect.

IMPACT: 2000/10 TO 2001/09

The NCLP&MT reports are utilized nationwide in the evaluation of pullet rearing nutrition and programs on growth and development of commercial layer strains. These programs are being used as guidelines by the food service industry to satisfy the welfare standards they are imposing on their egg suppliers.

PUBLICATIONS: 2000/10 TO 2001/09

1. Jones, D.R., K.E. Anderson, and G.S. Davis, 2001. The effects of genetic selection on production parameters of Single Comb White Leghorn hens. *Poultry Sci.* 80:1139-1143.
2. Bell, D. D., P. H. Patterson, K. W. Koelkebeck, K. E. Anderson, M. J. Darre, J. B. Carey, D. R. Kuney, and G. Zeideler, 2001. Egg marketing in national supermarkets: Egg quality-Part 1. *Poultry Sci.* 80:383-389.
3. Patterson, P. H., K. W. Koelkebeck, D. D. Bell, J. B. Carey, K.E. Anderson, and M.J. Darre, 2001. Egg Marketing in National Supermarkets: Specialty eggs - Part 2. *Poultry Sci.* 80:390-395.
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5. Davis, G. S., K. E. Anderson, and A. S. Carrol, 2000. The Effects of Long Term Caging and Molt of Single Comb White Leghorn Hens on Heterophil to Lymphocyte Ratios, Corticosterone and Thyroid Hormones. *Poultry Sci.* 79:514-518.
6. McAvoy, K.C., P. A. Curtis, K. M. Keener, K. E. Anderson, and D. E. Conner, 2001. Comparison of quality and functionality of traditionally and cryogenically cooled shell eggs. *Poultry Sci. Suppl.* 80:55. (abstract)
7. Hughes, L. A., K. E. Anderson, and P. A. Curtis, 2001. The effect of cryogenic cooling with carbon dioxide on the USDA grade and microbial load of shell eggs in the commercial setting. *Poultry Sci. Suppl.* 80:54. (abstract)
8. Anderson, K. E., B. W. Sheldon, and K. Richardson, 2001. Effect of Termin-8 anti-microbial preservative on the growth of commercial white and brown egg type laying strains. *Poultry Sci. Suppl.* 80:88. (abstract)
9. K.E. Anderson, G.S. Davis, and S. Hudson. 2001. Effect of dietary chitosan on production characteristics and egg proportions and quality from commercial white egg laying strains. *Poultry*

Sci. Suppl. 80:88. (abstract)

10. Fosnaught, M. H., and K. E. Anderson, 2001. Interaction of increased Ca and P regimens on commercial strains of layers housed at various densities. Poultry Sci. Suppl. 80:89. (abstract)

11. Anderson, K. E., 2001. Report on Pullet Rearing Period: 34th North Carolina Layer Performance and Management Test. Vol. 34, No. 2, February 2001.

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ACCESSION NO: 0152013 SUBFILE: CRIS
PROJ NO: NC06184 AGENCY: CSREES NC.
PROJ TYPE: HATCH PROJ STATUS: REVISED
START: 01 OCT 2001 TERM: 30 SEP 2006 FY: 2000

INVESTIGATOR: Anderson, K. E.

PERFORMING INSTITUTION:
POULTRY SCIENCE
NORTH CAROLINA STATE UNIV
RALEIGH, NORTH CAROLINA 27695

MAXIMIZATION OF LAYING HEN PERFORMANCE, ECONOMIC RETURN, AND EGG QUALITY

OBJECTIVES: Determine methods to optimize the productive potential, economic return, and egg quality of commercial strains of egg-type chickens by manipulation of pullet and layer nutrition, physical environment, husbandry practices, induced molt programs and shell egg processing factors.

1) Determine the relationship between body size and age at sexual maturity on subsequent layer performance and egg mass produced. 2) Determine the effects and interactions of strain, house type, density, husbandry practices, and layer nutrition on production and economics. 3) Determine the effects and interactions of induced molt programs on production, behavior, and economics. 4) Determine the effects of current egg processing technology on the physical quality and microbiological safety of shell eggs. 5) Examine alternative manure disposal systems.

APPROACH: Commercial strains of white and brown egg-type chickens and the eggs that they produce will be utilized. Pullets will be reared in environmental control housing with various combinations of nutritional or management programs which affect the productivity of the layers at the Poultry Research Unit of the Piedmont Research Station at Salisbury, NC. The factors could

include: light programs, dietary regimen, body weight program, molt techniques, husbandry practices, environment control programs, and egg handling programs. Pullets and layers will be managed as close to commercial industry standards as possible except when deviations are needed to accomplish the research objectives. Pullet body weights, feed consumption and mortality as well as hen feed consumption, egg production, egg quality and livability data will be collected on each flock. Productivity will be defined by various measurements of body weight, skeletal structure, feed consumption, immune competence, physiological health, and egg production criteria. The welfare status will be defined by the behavioral profile and hormonal response of the birds. Egg quality will be defined by the USDA egg quality standards, physical shell and membrane measurements, and through microbiological testing of the shell and contents. The potential of poultry manure as an organic fuel source will be evaluated from commercial sources and based upon governmental standards for emissions. The general experimental design will be a factorial arrangement which will allow for examination of multiple factors simultaneously.

NON-TECHNICAL SUMMARY: NA

PROGRESS: 1999/10 TO 2000/09

The Final Report for the 33rd North Carolina Layer Performance and Management Test Indicates that the density effects on specific strains has become more apparent in the strains available to the egg industry. The rapid egg cooling field trials have been completed using the newly designed cooling tunnel by Praxair. The anti microbial effects have been evaluated and versus traditional cooling there is a 3 log reduction in microbial loads with rapid cooling. The first full trial using the avian cancer model has been completed. The model has been shown to be effective and preliminary evaluations are positive in the evaluation of chemopreventive agents.

IMPACT: 1999/10 TO 2000/09

The NCLP&MT reports are being utilized nation wide in the evaluation of density standards being imposed on the egg industry by the food service industry. The Cryogenic cooling process is commercially available to the egg industry

PUBLICATIONS: 1999/10 TO 2000/09

1. Keener, K. M., J. D. Lacrosse, P. A. Curtis, K. E. Anderson, and B. E. Farkas, 2000. The Influence of Rapid Air Cooling and Carbon Dioxide Cooling and Subsequent Storage in Air and Carbon Dioxide on Shell Egg Quality. *Poultry Sci.* 79:1067-1071.
2. Fosnaught, M.H., and K.E. Anderson, 2000. Influence of increased Ca and P regimens during the rearing and lay cycle on production and bone parameters in laying hens of different strains. *Poultry Sci. Suppl.* 79:40 (abstract)
3. Tharrington, J.B., P.A. Curtis, and K.E. Anderson, 2000. The relationship of egg shape to shell strength. *Poultry Sci. Suppl.* 79:59-60 (abstract)
4. Davis, G.S., K.E. Anderson, and S. Hudson. 2000. The effects of dietary chitosan on production characteristics in table egg pullets and laying hens. *Poultry Sci. Suppl.* 79:61 (abstract)
5. Anderson, K. E. and K. Richardson, 2000. Effect of Termin-8 compound on the microbiological and physical quality of shell eggs from commercial egg laying chickens. *Poultry Sci. Suppl.* 79:105

(abstract)

6. Jones, D., M. H. Fosnaught, and K. E. Anderson, 2000. Effects of stress on commercial layer pullet performance and stress response. Poultry Sci. Suppl. 79:86 (abstract)
7. Anderson, K. E., 2000. Hatch and Serology Report of the Thirty Fourth North Carolina Layer Performance and Management Test: Summary. Vol. 34, No. 1, November 2000.
8. Anderson, K. E., 2000. Final Report of the Thirty Third North Carolina Layer performance and Management Test: Production Report. Vol. 33, No. 4. October 2000.

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ACCESSION NO: 0404010 SUBFILE: CRIS
PROJ NO: 6612-32000-026-00D AGENCY: ARS 6612
PROJ TYPE: USDA INHOUSE PROJ STATUS: NEW
START: 31 JAN 2001 TERM: 30 JAN 2006 FY: 2001

INVESTIGATOR: GAST R K; MITCHELL B W; SWAYNE D E

PERFORMING INSTITUTION:
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DETECTION AND CONTROL OF SALMONELLA ENTERITIDIS IN POULTRY

OBJECTIVES: Develop improved methods for detecting Salmonella enteritidis (SE) infections in laying flocks and SE contamination in eggs. Characterize how, where, when, and in what numbers egg contamination by SE occurs. Reduce airborne dust and SE in poultry hatching cabinets and breeder houses using an electrostatic space charge system (ESCS), and determine the mechanism by which ESCS kills airborne and surface SE.

APPROACH: Chickens will be infected with a range of doses of various SE strains by oral inoculation, horizontal contact with infected birds or contaminated environments, or exposure to contaminated air sources. Eggs and egg fractions will be experimentally contaminated with SE. Samples will be subjected to bacteriological and serological testing to evaluate the efficacy of SE detection technologies and to characterize SE deposition in eggs. Optimum designs for use of the ESCS to reduce dust and pathogens including SE in poultry hatcheries will be determined in cooperation with commercial poultry integrators and breeders. The mechanism by which the ESCS inactivates airborne and surface SE, and biofilms, and the associated LD50 dose, will be determined.

Effectiveness of the ESCS for reducing egg contamination and airborne transmission of SE will be determined in a small breeder house. Previously was 6612-42000-035-00D (05/01).

PROGRESS: 2000/10 TO 2001/09

1. What major problem or issue is being resolved and how are you resolving it? The objective of this project is to develop improved methods for preventing, detecting, and controlling infections of chickens with *Salmonella enteritidis* (SE) and the associated production of SE contaminated eggs. Among the specific goals of the research are determining the processes and mechanisms by which SE infects chickens, spreads vertically and horizontally, and is deposited in eggs; characterizing the nature of SE contamination of eggs; developing more sensitive and specific diagnostic tests for identifying SE infections of chickens and for detecting SE contamination of eggs; and developing electrostatic space charging technology to diminish airborne dust and pathogens - including SE throughout - poultry hatching and housing facilities. 2. How serious is the problem? Why does it matter? The association between human illness caused by SE and the consumption of contaminated poultry products is an important international public health and economic problem. In recent years, SE has been among the *Salmonella* serotypes most often reported to cause human illness. Eggs have been the most frequently implicated sources of human SE infections in the United States. As food-borne transmission of SE threatens both the safety of consumers and the ability of poultry producers to market their products, the formulation and implementation of effective control strategies for reducing the incidence of SE infections in chickens has been identified as an urgent priority by both government and industry. 3. How does it relate to the National Program(s) and National Component(s)? National Program 108, Food Safety (100%) This research contributes to the Microbial Pathogens component of the Food Safety National Program by providing scientists (veterinary, food, and agricultural), regulatory agency officials, and the poultry industry with urgently needed tools to understand, prevent, detect, and control SE infections of chickens. 4. What were the most significant accomplishments this past year? A. Single most significant accomplishment during FY 2001. Replicated trials conducted in a small treatment chamber showed that an electrostatic space charge system (ESCS) reduced biofilms developed on stainless steel from poultry carcass rinses by 97.3% in 2 hours and 99.8% in 3 hours. These results are comparable to those obtained by existing disinfection chemicals and indicate that the ESCS could potentially be used as a non-chemical treatment to reduce pathogens in biofilms which develop in poultry egg or meat processing areas. B. Other significant accomplishments. Because bacteria grow much more rapidly in egg yolk than in albumen, the location at which SE cells are deposited is critical for determining how quickly refrigeration must lower internal egg temperatures. After experimentally infecting groups of laying hens with SE strains of different phage types, we found SE more often in yolk than in albumen. Most contaminated eggs contained fewer than 1 SE cell per ml. These results suggest that refrigeration standards must address the possibility that SE may sometimes be deposited in yolk. When contaminants were experimentally introduced into egg contents, we observed rapid multiplication in yolk and extended persistence in albumen for a diverse assortment of SE strains of several phage types. This suggests that egg refrigeration standards may not need to address much potential variability in growth and survival characteristics between SE strains, but preventing disease transmission by eggs requires rapid refrigeration in combination with other control measures. When we compared the levels of serum antibodies induced in experimentally infected hens to the frequency

at which they laid eggs contaminated by SE, we found that the relationship between these two parameters was not very consistent. Accordingly, although antibody tests are useful tools for preliminary screening of laying flocks to detect SE infection, the magnitude of the antibody response by individual hens does not predict the overall risk of egg contamination associated with the flock.

5. Describe the major accomplishments over the life of the project including their predicted or actual impact. This project provided the first definitive experimental documentation that hens systemically infected with SE could produce internally contaminated eggs. Scientists found that SE infections can be highly persistent in both chicks and hens and elicit long-lasting antibody titers. The project developed and assessed the sensitivity and predictive value of methods for detecting specific antibodies in serum and egg yolks from infected hens. The project developed effective and practical bacteriological methods for consistently detecting very small numbers of SE contaminants in eggs. Efficient killed vaccines were developed and evaluated for reducing the susceptibility of laying hens to SE infection. Studies assessed the relationship between phage type of SE isolates and their virulence, infectivity, and invasiveness in chicks. One scientist determined that air movement can mediate the horizontal transmission of SE infection. An ESCS was developed under a CRADA to reduce airborne dust and microorganisms in hatching cabinets. The ESCS has been shown to have effectiveness comparable to a 95% media filter for removing dust in laboratory experiments in hatching cabinets and transmission cabinets and equal or better effectiveness for removing airborne bacteria and Salmonella. The ESCS reduced airborne SE in an isolation room with caged layers approximately 95%. The kill rate of the ESCS on airborne and surface SE at close range has been shown to be 98% or more. The ESCS has been patented and an exclusive license for poultry applications has been approved with BioIon, Inc. to manufacture and distribute the system.

6. What do you expect to accomplish, year by year, over the next 3 years? During FY2002, we will establish how the growth patterns of SE inside eggs affects the development and application of faster methods for detecting contamination. During this year we also will study the effectiveness of the ESCS for pathogen reduction in egg rooms and upsize pathogen reduction hatchery studies to include followup of chicks from ionizer treated hatching cabinets to full-sized production houses. We will also determine the effectiveness of the ESCS for reducing pathogens and airborne disease transmission in a small scale breeder house and investigate the mechanism by which ionization inactivates SE. Effectiveness of the ESCS for reduction of biofilms in large open areas will be determined. For FY2003, we will evaluate how the patterns of deposition and multiplication of SE isolates in egg contents affects the probable effectiveness of proposed standards for egg refrigeration. We will also design an ESCS for full sized breeder houses and test effectiveness for pathogen and dust reduction. In FY2004, we will seek to develop and apply improved models and methods for producing experimental SE contamination of eggs, detecting SE contaminants in eggs, and detecting specific antibodies in infected chickens. We will also study the effectiveness of self-cleaning ESCS devices in poultry production areas and test the effectiveness of electrostatically-enhanced high volume air samplers for airborne pathogens.

7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product? Completed commercial hatcher tests of ESCS with two commercial poultry production companies. CRADA partner initiated patent applications for the ESCS for several foreign countries. Participated in the 2001 International Poultry and Egg Exhibition January 17-19, 2000

where the ESCS and related posters were displayed in a commercial exhibit for hatchery equipment. Recent developments in methods for culturing eggs and other poultry samples to detect SE contaminants have been incorporated into the testing protocols of a national flock testing program under development by FDA. 8. List your most important publications in the popular press (no abstracts) and presentations to non-scientific organizations and articles written about your work (NOTE: this does not replace your peer-reviewed publications which are listed below) Report, "Electrostatic space charge system for reducing airborne pathogens and dust", FLC Awards Page, <http://flc2.federallabs.org/servlet/newContentObjServlet?LinkCoArID=2001-05-29-15-58-08-480-mchambers&CoArRegion=National&parentID=2001-05-24-13-47-50-770-mchambers>, May 2001. Report, "Researchers honored for transferring technologies." ARS News and Information, <http://www.ars.usda.gov/is/pr/2001/010501.htm>, May 2001. Presentation, "Reducing airborne dust and bacteria in the hatchery." Georgia International Poultry Course, Athens, Georgia 2001. Presentation, "Pathogen reduction in poultry housing." Nebraska Poultry Industries, Columbus, Nebraska, 2001. Presentation, "Epidemiology and ecology of Salmonella enteritidis in poultry: general issues and research needs." Public Meeting on Salmonella Enteritidis Research, Sponsored by U. S. Food and Drug Administration, Atlanta, Georgia, 2000. Presentation, "The evolving application of egg culturing for detecting Salmonella enteritidis infection in laying flocks." Salmonella Isolation and Identification Workshop. Sponsored by Georgia Poultry Laboratory and National Poultry Improvement Plan, Oakwood, Georgia, 2001.

PUBLICATIONS: 2000/10 TO 2001/09

1. Gast, R.K., Petter, J.G., Holt, P.S. Frequency and location of Salmonella enteritidis contamination in eggs associated with various routes of experimental infection of laying hens. Program of the annual meeting of the American Association of Avian Pathologists. 2001. p. 21. Abstract.
2. Gast, R.K., Holt, P.S. Deposition of phage type 4 and 13a Salmonella enteritidis strains in the yolk and albumen of eggs laid by experimentally infected hens. Avian Diseases. 2000. v. 44. p.706-710.
3. Gast, R.K., Holt, P.S. Multiplication in egg yolk and survival in egg albumen of Salmonella enterica serotype Enteritidis strains of phage types 4, 8, 13a, and 14b. Journal of Food Protection. 2001. v. 64. p.865-868.
4. Gast, R.K., Holt, P.S. The relationship between the magnitude of the specific antibody response to experimental Salmonella enteritidis infection in laying hens and their production of contaminated eggs. Avian Diseases. 2001. v. 45. p.425-431.
5. Gast, R.K., Nadir, M.S., Jolly, M.E., Holt, P.S., Stone, H.D. Serological detection of experimental Salmonella enteritidis infections in laying hens by fluorescence polarization and enzyme immunoassay. Poultry Science. 2001. v. 80. p.1044. (Abstract).
6. Mitchell, B.W. Emerging technology electrostatic space charge system for pathogen reduction. Institute of Food Technology Abstract. <http://ift.confex.com/ift/2001/techprogram/paper/6385.htm>. 2001.
7. Mitchell, B.W., Holt, P.S., Seo, K.H. Effectiveness of electrostatic space charge for reducing dust in a caged layer room. Journal of Applied Poultry Research. 2000. v. 9. p.292-296.
8. Ricke, S.C., Birkhold, S.G., Gast, R.K. Eggs and egg products. Downes, F. P., Ito, K., editors. American Public Health Association, Washington, DC. Compendium of methods for the microbiological examination of foods, 4th edition. 2001. p.473-481.

9. Seo, K.H., Mitchell, B.W., Holt, P.S., Gast, R.K. Bactericidal effects of negative air ions on airborne and surface *Salmonella enteritidis* from an artificially generated aerosol. *Journal of Food Protection*. 2001. v. 64. p.113-116.

ACCESSION NO: 0188875 SUBFILE: CRIS
PROJ NO: PEN03841 AGENCY: CSREES PEN
PROJ TYPE: HATCH PROJ STATUS: NEW
START: 01 JUL 2001 TERM: 30 JUN 2006

INVESTIGATOR: Mashaly, M. M.

PERFORMING INSTITUTION: POULTRY SCIENCE PENNSYLVANIA STATE UNIVERSITY
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OPTIMIZING MANAGEMENT PRACTICES TO ENHANCE PRODUCTION PERFORMANCE
AND IMMUNITY IN ORDER TO IMPROVE POULTRY HEALTH UNDER STRESSFUL
CONDITIONS

OBJECTIVES: 1) To investigate the role of photoperiod and melatonin in alleviating the negative economic impact of different stressors on broiler performance, immunity and health. 2) To study the influence of induced molting in laying hens on subsequent effects of different stressors on production performance, immunity, health and hormone profiles. 3) To determine the mechanisms involved in the initiation of immune responses, including the roles of cytokines and hormones, under different stressful conditions.

APPROACH: In studying the effect of photoperiod on broiler performance under stressful conditions, CobbxCobb broiler chicks will be used and exposed to either continuous light (23L:1D) or intermittent light (1L:3D). Half of the birds in each group will be exposed to 35C (heat stress) from 21 to 42 days of age, the other half will be exposed to 24C (control). Production parameters such as body weight, feed consumption, feed conversion, and mortality will be measured weekly. Immune parameters such as cytokines and antibody production will be measured at 3 and 6 weeks of age. In studying the effect of melatonin on broiler performance under stressful conditions, again CobbxCobb broiler chicks will be used. They will be kept under 23L:1D and receive in the feed either 0, 20, 40, or 60 ppm melatonin. The same heat stress treatment mentioned above will be applied as well as production and immune parameters. In order to study the influence of induced molting in laying hens on subsequent effects of different stressors on production performance, immunity, health and hormone profiles, 72-week-old laying hens will be induced molted and following period of egg laying, they will be exposed to different kinds of stresses. Percent hen-day egg production, percentage hen-housed egg production, egg shell quality (specific gravity method), albumin quality, albumin height, Haugh units, feed consumption, feed per dozen eggs, and percent mortality will be measured throughout the experiment. Corticosterone T3, T4, and prolactin will be measured in the plasma at different times during the experiment. Antibody production and cell

mediated immunity will also be measured. In order to study the mechanisms involved in the initiation of immune responses under different stressful conditions, Cornell K-strain Single Comb White Leghorn immature male chickens will be used. The birds will be housed in batteries with food and water available ad libitum, and exposed to 16L:8D per day. Birds will be exposed to different environmental and management stressors. Different high temperatures will be used as the environmental stressor and different population densities will be used as the management stressor. Different T-independent and T-dependent antigens will be used to stimulate humoral immunity in these chickens. Blood and spleen samples will be collected at different time periods post-injection. Specific cytokines will be measured in all samples collected as appropriate. Antibodies against the different antigens will be measured in all plasma samples collected. Percentage of different lymphocyte subpopulations will be measured in all blood and spleen samples.

NON-TECHNICAL SUMMARY: Certain management practices can be optimized to reduce stress and improve poultry health. The purpose of this study is to determine and apply the optimum standards of certain management practices under stressful conditions in order to improve poultry health and production.

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ACCESSION NO: 0188709 SUBFILE: CRIS
PROJ NO: VA-135638 AGENCY: CSREES VA.
PROJ TYPE: HATCH PROJ STATUS: NEW
START: 01 JUL 2001 TERM: 30 JUN 2006 FY: 2001

INVESTIGATOR: MCELROY, A. P.

PERFORMING INSTITUTION:
ANIMAL POULTRY SCIENCES
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MORPHOLOGICAL CHARACTERIZATION AND DIETARY CAPSAICIN POTENTIATION OF
INTESTINAL IMMUNITY IN CHICKENS.

OBJECTIVES: Describe the response of mast cells and eosinophils in the innate intestinal inflammatory immune response to coccidia or Salmonella infection in commercial broilers.

Characterize the non-specific or specific effector functions of mast cells and eosinophils in protective intestinal immune responses to secondary exposure to homologous challenges with coccidia species or Salmonella. Determine the role of mast cells or eosinophils in immunopathology of coccidia. Evaluate the effect of dietary capsaicin administration on intestinal immune responses and resistance to coccidia or Salmonella.

APPROACH: Naive or immunized commercial broiler chickens will be challenged with Salmonella or selected Eimeria species of coccidia. Intestinal tissue will be collected on selected days post-challenge for morphological evaluation and microbiologic culture or lesion scoring for Salmonella or Eimeria, respective to pathogen. Capsaicin will be included in commercial broiler diets for selected periods of time pre- or post-challenge. Intestinal tissues will be examined by light microscopy for alterations in structure or cellular influx and protection to infection by Salmonella or coccidia species will be evaluated by culture or lesion scoring.

NON-TECHNICAL SUMMARY: Although Salmonella and coccidia present problems to the commercial poultry industry from economic, food-borne illness, or bird productivity standpoints, relatively little is understood concerning the interactions between these pathogens and the host at the level of the intestinal immune response. The purpose of this research is to describe the effector functions of mast cells and eosinophils in innate intestinal immune responses to Salmonella and coccidia in broiler chickens.

PROGRESS: 2000/10 TO 2001/09

While live oocyst vaccination provides a viable alternative to anticoccidial usage and resulting drug-resistance in the commercial poultry industry, complete resistance to coccidia is difficult to achieve due to immunovariability between vaccine species and field strains. Immunovariability between coccidia species in vaccines and those found in poultry rearing facilities has emerged as a potential complication associated with vaccination. Additionally, there have been reports of coccidia-like impacts on performance with minimal appearance of coccidia lesions in the field environment. The purpose of the experiments conducted was to evaluate the host response to different field isolates of Eimeria acervulina (EA) by associating classical mucosal lesions with decreased body weight gain in infected broilers, to compare the host response of two commercial broiler breeds to the field isolates of EA, and to determine if other vectors (bacterial) may contribute to a differential host response. Experiments were conducted comparing two isolates of EA, EA1 and EA2, obtained from commercial poultry rearing facilities. In three experiments, commercial broilers chicks were divided into control (non-challenged) and EA1 or EA2 challenged groups at 14 days of age. In all 3 experiments, EA1 resulted in significantly (P is less than 0.05) higher lesion scores than EA2, however weight gain of EA1 challenged birds was not significantly different from controls. EA2 challenged birds had significantly higher lesion scores than control birds in Expts 1 and 3, with no lesions characteristic of classical EA infection in Expt 2. EA2 resulted in significantly decreased weight gain as compared to EA1 or control in Expt 3. While EA1 resulted in classical EA lesions with no significant difference in weight gain, EA2 resulted in few classical lesions with significant depression of weight gain. Subjective observation of intestines from EA2 challenged birds was suggestive of a severe secretory intestinal response and weakened intestinal strength. In

Expt 4, EA2 oocysts were cleaned with 5.25 percent sodium hypochlorite to evaluate the possibility of an external bacterial factor contributing to the observed detrimental affects in the presence of few lesions. Birds were challenged with bleached or non-bleached EA2. Although there was no significant difference in lesion scores between EA2 challenged groups, non-bleached EA2 resulted in significantly decreased weight gain as compared to bleached. These data are indicative of immunovariability between different isolates of the same coccidia species that result in differences in clinical lesions and performance. Furthermore, the results indicate differences in the host response that may contribute to the pathogenicity and suggest that standard coccidia lesion scoring procedures may not be applicable for evaluation of the severity of clinical infection with all Eimeria isolates.

IMPACT: 2000/10 TO 2001/09

These findings contribute to the understanding of the complex intestinal immune response to coccidia in commercial poultry and depict the diversity of the host response that may exist to different environmental isolates of the same coccidia species. Additionally, the findings suggest differential responsiveness exists in different breeds of commercial broilers. Continued description of the intestinal immune response to this pathogen will allow for more effective vaccination or control strategies.

PUBLICATIONS: 2000/10 TO 2001/09

Morris, B.C., H.D. Danforth, D.J. Caldwell, and A.P. McElroy, 2001. Differential Intestinal Response to Eimeria acervulina Challenge in Broiler Chickens. Poultry Sci. 80: Suppl. 1.

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ACCESSION NO: 0164533 SUBFILE: CRIS
PROJ NO: TEX08311 AGENCY: CSREES TEX
PROJ TYPE: HATCH PROJ STATUS: REVISED
START: 10 MAY 2001 TERM: 09 MAY 2006 FY: 2000

INVESTIGATOR: Ricke, S. C.

PERFORMING INSTITUTION:
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FOODBORNE SALMONELLA SPP. REDUCTION IN POULTRY PRODUCTION

OBJECTIVES: A. *Salmonella* virulence expression in molted birds, objectives are 1) to determine if addition of dietary moderate zinc-low calcium will prevent colonization of *Salmonella* Enteritidis in the crop of chickens undergoing molting and what characteristics in the crop microenvironment are associated with this type of induced molt, and 2) to understand the potential role of that crop for *Salmonella* Enteritidis virulence expression while birds are undergoing molting and if key characteristics in the chicken crop microenvironment can be linked with limiting *S. Enteritidis* colonization and virulence expression. B. The role of methanogens in establishment of anaerobic microflora, the objectives are 1) to determine when methanogens become a part of the cecal microflora, what characteristics in the cecal microenvironment are associated with establishment of methanogens and enumerate the methanogen populations, and 2) to determine how stable the cecal methanogen population is by looking at whether feed deprivation alters methanogen activity while birds are undergoing fasting and if key characteristics in the chicken cecal microenvironment can be linked with decreased methanogen populations. The hypothesis is that the final stages of cecal obligate anaerobic microfloral development will coincide with the emergence of methanogens and their presence will signify completion of establishment of the dynamic complex anaerobic population characteristic of mature birds. In addition, we hypothesize that decreases in numbers of methanogens signifies the beginning of instability in the cecal anaerobic microflora.

APPROACH: A. *Salmonella* virulence expression in molted birds: the idea here is to compare the indigenous microbial response in crops of birds that have been molted either by feed deprivation or using the moderate Zn diet approach. The hypothesis is that feed intake will be retained in the birds molted via moderate Zn addition and the crop microflora will continue to be actively fermenting to the point of being inhibitory to *Salmonella* Enteritidis colonization and invasion. Based on our earlier work we hypothesize that the key indicators of an active fermentation in the crop are low pH and a high concentration of lactate. Therefore, in addition to enumerating *Salmonella* Enteritidis recovered after infection in the different treatment groups we plan to thoroughly examine the microenvironment of the crops from the birds in these different treatment groups. This will be done by quantitating fermentation products and enumeration of the crop *Lactobacilli*. Whether these key characteristics in the chicken crop microenvironment can be linked with limiting *S. Enteritidis* in vivo invasion will be determined by examining virulence activity of *Salmonella* Enteritidis (*hilA-lacZY* transcriptional operon fusion) with a gene fusion strain for in vitro assays of crop contents. B. The role of methanogens in establishment of anaerobic microflora: The overall experimental concept in this proposal is to determine when methanogens appear in the ceca as birds age on different diets and how stable the methanogen population is during drastic dietary changes. To accomplish this, methanogens will be enumerated from three different scenarios: 1) newly hatched chicks on different diets; 2) newly hatched chicks given a cecal transfer from adult birds and 3) feed deprived molted laying hens. These three scenarios represent the commercial settings where the cecal microflora are considered important in resisting colonization by foodborne pathogens, namely, young chicks with or without a probiotic and laying hens undergoing molting. In the proposed work we plan to thoroughly examine the microenvironment of the ceca in the three groups of birds. This will be done by quantitating fermentation products (VFA, lactate, pH, and Eh) and in addition to quantifying methanogens, enumerate microbial components of the ceca including *Lactobacilli*, *Bifidobacteria*, *Escherichia coli*, total aerobic and anaerobic bacteria. The rationale for

these choices is that aerobic bacteria and *E. coli* represent facultative populations that are generally early colonizers of the chick ceca, followed by lactobacilli and bifidobacteria and finally the strict anaerobes. These subgroups of organisms in addition to the fermentation products should give us a representative profile of the microbial population changes occurring in the ceca prior to and during the establishment of methanogens. Whether these characteristics in the chicken cecal microenvironment can be linked with establishment of methanogens will be the outcome of this component of the proposal.

NON-TECHNICAL SUMMARY: Specific research plans reflect an integrated approach for controlling *Salmonella* in the early stages of production of poultry. This project will provide A) ideas for management alternatives to reduce molting as a risk for *S. Enteritidis* contamination, and B) understanding of the role of methanogens in the development of the cecal microflora, the natural microflora being inhibitory to *Salmonella*.

PROGRESS: 2000/01 TO 2000/12

The incidence of foodborne disease is increasing yearly, despite the growing body of information regarding the most common foodborne pathogens. During its life cycle *Salmonella* spp. can encounter various environmental stress conditions which may have dramatic effects on their survival and virulence. One of the potential stress conditions that can be frequently encountered by foodborne pathogens is exposure to starvation stress. We have found that virulence expression of *S. enteritidis* and *S. typhimurium* to various stress conditions associated with food systems or host environments could be greatly increased by exposure to SCFA, and further enhanced by feed deprivation and the resulting microenvironment in the crop of molted laying hens. We continue to investigate the molecular response of *Salmonella* to gastrointestinal environmental conditions.

IMPACT: 2000/01 TO 2000/12

This research is expected to contribute to the understanding of virulence mechanisms of *S. typhimurium* and may provide a scientific basis for developing more optimal strategies to control the foodborne pathogen.

PUBLICATIONS: 2000/01 TO 2000/12

1. Durant, J.A., V.K. Lowry, D.J. Nisbet, L.H. Stanker, D.E. Corrier, and S.C. Ricke. 2000. Late logarithmic *Salmonella typhimurium* HEp-2 cell-association and invasion response to short chain volatile fatty acid addition. *J. Food Safety* 20: 1-11.
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fusion response after incubation in a spent media from either *S. enteritidis* or a probiotic *Lactobacillus* strain. *J. Environ. Sci. Health*, B35: 599-610.

6. Durant, J.A., V.K. Lowry, D.J. Nisbet, L.H. Stanker, D.E. Corrier, and S.C. Ricke. 2000. Short-chain fatty acids alter HEp-2 cell association and invasion by stationary growth phase *Salmonella typhimurium*. *J. Food Sci.* 65: 1206-1209.

7. Kwon, Y.M., C.L. Woodward, S.D. Pillai, J. Pena, D.E. Corrier, J.A. Byrd, S.C. Ricke. 2000. Litter and aerosol sampling of chicken houses for rapid detection of *Salmonella typhimurium* using gene amplification. *J. Industrial Microbiol. Biotech.* 24: 379-382.

8. Kwon, Y.M., C.L. Woodward, D.E. Corrier, J.A. Byrd, S.D. Pillai, and S.C. Ricke. 2000. Recovery of a marker strain of *Salmonella typhimurium* in litter and aerosols from isolation rooms containing infected chickens. *J. Environ. Sci. Health*, B35: 517-525.

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Termination Year 2003

ACCESSION NO: 0186918 SUBFILE: CRIS
PROJ NO: MD-VTMD-9130 AGENCY: CSREES MD.
PROJ TYPE: OTHER GRANTS PROJ STATUS: NEW
CONTRACT/GRANT/AGREEMENT NO: 00-51110-9739 PROPOSAL NO: 2000-05442
START: 15 SEP 2000 TERM: 14 SEP 2003 FY: 2001 GRANT YR: 2000

INVESTIGATOR: HECKERT, R. A.; LILLEHOJ, H.; BABU, U.; SONG, W.; RAYBOURNE, R.

PERFORMING INSTITUTION:
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SALMONELLA IMMUNOBIOLOGY AND INTERVENTION STRATEGIES

OBJECTIVES: Our goals for this project are: Goal #1: Evaluate the host local immune responses to Salmonella infection and investigate the effects of various immunomodulating factors. Goal#2: Determine the effects of various vaccination and intervention strategies on the immune response and colonization, persistence and shedding of Salmonella in laying chickens. Goal #3: Examine the impact of forced molting on the immune status of commercial laying chickens.

APPROACH: The immune system is still the most powerful and effective system the host has in preventing and eliminating infections by microorganisms. Although SE infection may not result in serious illness in chickens, a carrier state may be established, suggesting that the immune system of the chicken is ineffective in completely preventing SE infection, invasion and shedding. We propose to systematically examine the immune system of the chicken before, during and after SE infection to gain a greater understanding of how the microorganism and the immune system interact. We will also examine mechanisms of altering this immune response in order to enhance the resistance to colonization, enhance the elimination of the microorganism and prevent shedding. Studies will not only take place under controlled laboratory conditions, but will also investigate the impact of the immune system on Salmonella infections of commercial laying chickens on farms. In recent years, SE has been the most commonly isolated Salmonella serotype in humans in the U.S.⁶ Between 1985 and 1991, eggs were the primary vehicle of SE infection in 82% of human food borne outbreaks.⁷ Control of SE in man will depend upon effective means of reducing SE in eggs. In order to effectively do this we must first understand the pathogenesis of Salmonella in poultry and the impact the immune system has on this infection. This could lead to strategies to modulate the immune system to better prevent and control Salmonella infections, thereby leading to effective pathogen reduction or elimination. We have established a consortium of researchers with expertise relevant to addressing the above research goals. This group will carry out a comprehensive evaluation of the role of the immune system in SE-elimination from various age groups of birds. In this proposal, we will investigate the potential of several intervention strategies for controlling SE infection in hens and determine their possible mechanisms of action. Additionally, the field component of this proposal is a unique feature, which has been identified as a key factor in the egg safety action plan (a federal initiative designed to reduce the threat of SE in shell eggs). Our proposed work includes examining the impact of forced molting on the immune system and SE in commercial laying hens. We have performed preliminary studies on various aspects of Salmonella-host interaction and have established the methodology necessary to carry out the investigations outlined in this proposal. This research should not only provide basic information on the pathogen-host cell interaction, but also give vital information on how the immune system of the chicken can be used to control or eliminate the spread of SE from animals to man.

NON-TECHNICAL SUMMARY: Salmonella enteritidis (SE) carried by chickens and shed into and onto shell eggs has become a major source of human intestinal infections. Despite a large amount of research, there are still no effective measures for preventing SE colonization, and we still lack an understanding of why Salmonella infected hens remain persistently infected. This study will investigate the immunobiology of Salmonella infections in laying chickens and develop novel immunomodulating strategies for the intervention of Salmonella colonization, persistence, shedding and egg contamination.

PROGRESS: 2001/01 TO 2001/12

In the last 20 years there has been an increase in human food-poisoning outbreaks attributable to *Salmonella enteritidis* (SE) in the United States. Epidemiological studies of this increase have indicated that grade A shell eggs are an important source of SE. Despite the tremendous efforts made by the poultry industry, no effective measures for elimination of SE colonization have been developed. The humoral immune responses after infection with SE have been extensively studied for diagnostic purposes. However, the fundamental mechanism of mucosal resistance to infection and clearance of SE from the gut has received scant attention. Protection from infection by SE through humoral mechanisms alone is unlikely, due to the organism being a facultative intracellular bacterium. There is enough evidence in various animal models that cell mediated immunity plays a major role in controlling *Salmonella* infection. In chickens, thus far, there is lack of detailed knowledge on the immune mechanisms involved in defense against *Salmonella* infection. Our studies thus far have supported earlier conclusions that natural infection produces weak and transient immune responses that are ineffective at preventing or clearing a *Salmonella* infection. We have found that immunization with a killed vaccine provides a better immune response than using a modified live vaccine. This immunity is better with respect to intestinal IgA (which is the main barrier to *Salmonella* colonization of the intestinal tract) and better in producing cellular immunity (that which is responsible for eliminating the infection). This is somewhat surprising, as traditional thinking indicated that killed vaccines were not effective at eliciting good cellular immunity. We are currently preparing several publications regarding these findings. A further goal in this research was to evaluate various methods of increasing the chick's natural resistance to infection. To this end we have been developing and evaluating various compounds that could be administered in ovo, to increase the innate immunity of the chick at hatch. One of the first substances we evaluated was a genetic adjuvant. This is a short stretch of nucleic acids containing many C and G bases in a particular motif. These sequences are bacterial in origin and have been shown in the mammalian system to up regulate the immune system. We have synthesized several of these sequences in various motifs and have shown that some of them are also powerful stimulants in activating avian cells. We have shown the CpG oligonucleotides to increase macrophage intracellular nitric oxide, increase expression of cell surface antigens and increase expression of IL-6 in vitro. Preliminary studies have also shown it to have similar effects when delivered in ovo. We are in the process of preparing a publication reporting this novel and important finding. As further goals in this project we are continuing to explore vaccination and other methods of increasing the immunity of the hatched chick, such that it is better able to resist *Salmonella* infection at hatch.

IMPACT: 2001/01 TO 2001/12

This research should not only provide basic information on the pathogen-host cell interaction, but also give vital information on how the immune system of the chicken can be used to control or eliminate the spread of *Salmonella* from animals to man.

PUBLICATIONS: 2001/01 TO 2001/12

No publications reported this period

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ACCESSION NO: 0403095 SUBFILE: CRIS
PROJ NO: 3602-32000-003-02S AGENCY: ARS 3602
PROJ TYPE: USDA COOPERATIVE AGREEMENT PROJ STATUS: NEW
CONTRACT/GRANT/AGREEMENT NO: 58-3602-9-146
START: 15 SEP 1999 TERM: 14 SEP 2003 FY: 2001 GRANT YR: 1999

INVESTIGATOR: LAY JR D C; PAJOR E

PERFORMING INSTITUTION: ANIMAL SCIENCE PURDUE UNIVERSITY WEST
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ANIMAL WELFARE IN FOOD PRODUCING ANIMALS

OBJECTIVES: The objective of this cooperative agreement research project is to determine the effect of specific management practices on farm animal welfare and productivity in poultry, swine and dairy cattle.

APPROACH: The impact of specific management practices (induced-molting in poultry, housing environments in swine, and introductions to the milking parlor in dairy) on animal welfare will be scientifically quantified. Effects will be determined using ethological, physiological, immunological and neurological methodologies. Behavioral measures will be collected using live observation and advanced video/computer technology. Computer software will be used to collect and manipulate data in preparation for statistical analyses. Laboratory techniques will consist of immunological assays, high performance liquid chromatography, radioimmunoassays, immunohistochemistry and neuron mapping.

PROGRESS: 2000/10 TO 2001/09

1. What major problem or issue is being resolved and how are you resolving it? 2. How serious is the problem? Why does it matter? 3. How does it relate to the National Program(s) and National Component(s)? 4. What were the most significant accomplishments this past year? D. Progress Report This report documents research conducted under a specific cooperative agreement between ARS and Purdue University. Additional details of research can be found in the report for the parent CRIS 3602-33000-002- 00D Ethology of Food Producing Animals. A second postdoctoral associate has been hired under this agreement, bringing expertise in poultry behavior from Europe that is not available in the U.S. The use of gestation stalls is banned in Europe and questioned in the U.S. for animal welfare reasons. A project with Dr. Ed Pajor, Purdue University, comparing confinement in gestation stalls or access to group areas during gestation is under analysis. Gilt cortisol, immune

function, and acuta phase response data is completed and will be presented at the 2002 National Animal Science Meeting. Gilt behavioral data and piglet immune function and behavioral data are being analyzed. This work will become part of a scientific data set that will be used to establish swine welfare standards by commercial users. With recent dairy expansions, the time that cattle are in holding areas waiting to enter the parlor has increased. A study in collaboration with Dr. Mike Schutz and Dr. Ed Pajor, Purdue University, investigated short term physiological and behavioral changes caused by the increased holding time (40 minutes or 2 hours). Data are being analyzed. This work will be useful to producers and extension agents during dairy expansions for advise on appropriate holding times prior to milking. A poultry behavior project in collaboration with Dr. Ed Pajor, Purdue University, that will investigate imprinting affects on chick behavior is underway. 5. Describe the major accomplishments over the life of the project including their predicted or actual impact. 6. What do you expect to accomplish, year by year, over the next 3 years? 7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product? 8. List your most important publications in the popular press (no abstracts) and presentations to non-scientific organizations and articles written about your work (NOTE: this does not replace your peer-reviewed publications which are listed below)

PUBLICATIONS: 2000/10 TO 2001/09

No publications reported this period.

ACCESSION NO: 0191950 SUBFILE: CRIS

PROJ NO: CALV-AH-198 AGENCY: CSREES CALV

PROJ TYPE: ANIMAL HEALTH PROJ STATUS: PENDING NEW

START: 01 NOV 2001 TERM: 31 OCT 2003

INVESTIGATOR: MCCOWAN, B.; JEFFREY, J.; CARDONA, C.

PERFORMING INSTITUTION:

POPULATION HEALTH & REPRODUCTION

UNIV OF CALIFORNIA (VET-MED)

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THE EFFECTS OF INDUCED MOLTING AND CHICKEN WELL-BEING

OBJECTIVES: The objective of this research is (1) to examine differences in chicken behavior and physiology under conditions of no fast-induced molting, natural molting and fast-induced molting under control (no-molt) and experimental (molt) conditions using individual chickens as their own controls to assess the amount of pain, suffering and/or stress in chickens under various types of molting and (2) to develop protocols for inducing molt that reduce pain, suffering or stress in chickens if fast-induced molting is found to

comprise chicken well-being.

APPROACH: Eight groups of three chickens housed in standard cages at the VMTRC will be the subjects of this study. Four experimental groups will be subjected to fast-induced molting. Two experimental groups will be subjected to no fast-induced molting in which a low caloric diet will be given to the chickens. Two control groups will be unmanaged and allowed to undergo natural molting. During all experiments, feed and water consumption, egg production and physical appearance will be monitored on a per cage basis. Data will be collected daily to monitor au natural inanition and to follow the progress of the molt. Stage 1. Normative data on chicken behavior, both social and vocal interactions, will be collected on and analyzed from video and audio tape to develop a comprehensive ethogram for use in the subsequent stages. Dominance or pecking order will be determined for each group to account for its effects on differential rates of behaviors by each individual. These normative data are important because little is known on the types or rates of behaviors and vocalizations of chickens that are indicative of psychological or physiological pain, suffering or stress. Examples of possible types and changes in rates of behaviors that might indicate increased stress include aggressive pecking, cage (non-nutritive) pecking, stereotyped pacing, head flicking and alarm vocalizations. Stage 2. Chickens will be subjected to a housing and lighting program that typically would be used by the poultry industry during normal production. During this stage, behavioral and vocal data will be collected for one hour twice on three days per week on both the types and rates of aggressive and alarm behaviors and vocalizations. Stage 3. Chickens will be subjected to the different treatments and behavioral and vocal data will be collected as described above. Experimental groups will be molted by withdrawing feed, or by a low caloric diet feeding, under the housing and lighting conditions typical of an induced molting program used by the poultry industry. The control groups will be similarly subjected to the housing and lighting conditions but feed will not be withdrawn. For all groups, data will also be collected on body weight, feather status and body temperature during Stages II and III in order to monitor molting status. Blood samples will be drawn from subjects for subsequent hormonal analyses to measures cortisol levels, which is used as physiological indicator of chronic stress. Serum prolactin (PRL) levels will also be measured as a physiologic indicator of reproductive tract involution, which is an indicative of future reproductive performance and egg quality. Behavioral data will be analyzed from the videotapes using a focal animal and 10-second interval sampling regime. This regime will permit us to analyze both the types and rates of aggressive, alarm and other stress-related behaviors under control and experimental conditions with each chicken acting as her own control. Behavioral and physiological data will be statistically analyzed using mixed effects linear regression in S-Plus statistical software.

NON-TECHNICAL SUMMARY: There is deepening concern that the induced molting of egg-laying chickens is cruel. This management practice is widespread in the commercial industry of California and other states because it provides significant benefits to both the producer and the consumer, as well to the health of the chicken flock. The purpose of this study is to evaluate changes in the behavior and physiology of chickens under non-molt conditions and three types of molt conditions to assess the well-being of chickens subjected to induced molting.

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ACCESSION NO: 0181123 SUBFILE: CRIS
PROJ NO: NEB-13-146 AGENCY: CSREES NEB
PROJ TYPE: HATCH PROJ STATUS: NEW
START: 04 DEC 1998 TERM: 30 NOV 2003 FY: 2000

INVESTIGATOR: SCHEIDELER, S. E.

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FACTORS AFFECTING CALCIUM UTILIZATION IN THE AVIAN AND EGG SHELL QUALITY

OBJECTIVES: Goal: To develop nutritional regimens that will improve eggshell quality in commercial egg flocks during the second cycle of egg production. 1. Test potential beneficial effects of new feed additives such as phytase enzymes or 25 OH cholecalciferol on eggshell quality specifically during late first cycle and during the second cycle of lay. 2. Measure potential effects of natural estrogen like compounds from lignans in flaxseed on calcium utilization during late lay in laying hens. 3. Investigate the effects of Zinc-source and level on carbonic anhydrase activity and subsequent effects on eggshell quality into late first cycle and second cycle hens.

APPROACH: Laying flocks will be maintained in the Poultry Research facilities at the University of Nebraska for the conduct of the planned research. Applied nutrition trials will be conducted with various age birds fed diets differing in nutrient content.

NON-TECHNICAL SUMMARY: This project address dietary modifications in laying hens to improve egg shell quality. Dietary modifications include adaptation of new technologies such as phytase enzyme, 25 dihydroxy Vitamin D, and trace mineral proteinates potential benefits to eggshell quality. The purpose of the project is to improve egg shell quality since 6-8gg loss occurs between the time of lay through processing and packaging to the consumer.

PROGRESS: 2000/10 TO 2001/09

A good deal of time was spent on the development of a novel monocalcium phosphorus feed ingredient utilizing eggshells as the calcium source for this product. This process was refined and a patent is pending for the process and product at UNL. Bioavailability studies in broiler chicks and laying hens were conducted indicating an availability of greater than 100% compared to dicalcium phosphorus. Further studies have also been conducted with hatchery waste to produce the reaction to

produce monocalcium phosphorus. Studies were also conducted this year testing non-restrictive feeding programs for molting laying hens. Low salt, high fiber diets were fed to laying hens to induce molt and compared to typical feed molt feed restriction programs. Hens successfully went through their molt on the low sodium diets and then re-entered a 2nd cycle of egg production without total feed restriction.

IMPACT: 2000/10 TO 2001/09

The creation of a novel monocalcium phosphorus product from egg processing egg shell waste or hatchery waste has potentially tremendous positive benefits to the environment. The volume of this waste grows annually and disposal is difficult as fields become calcium saturated. Adding value to this waste to make it into a feed ingredient is economically and environmentally sound. The molting research helps address animal welfare concerns of consumers as the egg industry adopts the UEP Bird Welfare guidelines of non feed restrictive molts.

PUBLICATIONS: 2000/10 TO 2001/09

1. Scheideler, S.E., and P.R. Ferket. 2001. Phytase in broiler rations - Effects on carcass yields and incidence of tibial dyschondroplasia. *J. Appl. Poultry Res.* 9:469-475.
2. Puthongsiriporn, U., S.E. Scheideler, J.L. Sell and M.M. Beck. 2001. Effects of vitamin E and C supplementation on performance and immune and antioxidant status of laying hens during heat stress. *Poultry Science* 80:1190-1200.
3. Jalal, M., and S.E. Scheideler. 2001. Effect of phytase supplementation on egg production parameters and amino acid digestibilities. *Poultry Science* 80:1463-1471.
4. Novak, C. and S.E. Scheideler. 2001. Long-term effects of feeding flaxseed based diets. 1. Egg production parameters, components and eggshell quality in 2 strains of laying hens.
5. Scheideler, S.E., N. Ward and M.Jalal, 2001. Effects of Roche Ronozyme CT on Hyline W-98 laying hen performance when fed low phosphorus diets. *Poultry Science* 80:478 (abstract).
6. Puthongsiriporn, U. and S.E. Scheideler, 2001. Effects of ratios of dietary linoleic to linolenic acid on hen performance, mitogenic response and antibody production of White Leghorn hens against Newcastle disease vaccine. *Poultry Science* 80:169 (Abstract)
7. Scheideler, S.E.,M.A. Jalal and E. Pierson. 2001. Strain response of laying hens to varying dietary energy with and without enzyme. *International Poultry Scientific Forum* p. 20 (Abstract).
8. Ash, J.A., and S.E. Scheideler, 2001. Bioavailability assessment of eggshell derived monocalcium phosphate. *International Poultry Scientific Forum* p. 20 (Abstract).

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Termination Year 2002

ACCESSION NO: 0177174 SUBFILE: CRIS
PROJ NO: IOWV-109-05-52 AGENCY: CSVM IOWV
PROJ TYPE: STATE PROJ STATUS: TERMINATED
START: 01 JUL 1997 TERM: 30 JUN 2002 FY: 1999

INVESTIGATOR: KRAMER, T.

PERFORMING INSTITUTION:
VETERINARY MEDICINE
IOWA STATE UNIVERSITY
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LIVE VACCINE AGAINST EGG-TRANSMISSION OF SALMONELLA ENTERITIDIS

OBJECTIVES: To prevent spread of Salmonella between laying hens. To prevent food poisoning from Salmonella contaminated eggs.

APPROACH: Develop and test a live, heterophil attenuated Salmonella enteritidis vaccine. To determine safety of vaccine for mice as a model for human safety.

PROGRESS: 1997/07 TO 2002/06

Food poisoning caused by poultry meat and eggs contaminated with Salmonella enteritidis (SE) are the leading causes of food poisoning in the U.S. and in the developed world. We postulated that fecal shedding and egg transmission of SE can be reduced by vaccination with a live, attenuated SE vaccine. The goal of this project was to develop a safe and effective live Salmonella enteritidis vaccine as a safeguard against food poisoning of poultry origin. The objectives of the project were to: 1) improve the heterophil and adapted SE vaccine (HASE); 2) to test the improved HASE vaccine by long-term monitoring of chicken feces, egg shells and egg contents; 3) to assess cloacal vs. vertical (transovarian) SE contamination of eggs; and 4) to determine the virulence/avirulence of the HASE in mammalian animal models. Objectives 1-3 were fully met in 1997. Preliminary data were gathered on the mammalian safety of the HASE vaccine. Specific objectives for 1998-1999 research were: 1) Continue work on demonstration of human safety of HASE vaccine TK 605 using a mouse model; 2) Investigate cellular and molecular basis for mechanism of action of HASE TK 605 vaccine by probing into vaccine-heterophil interactions, by comparing phagocytic indices of SE and HASE at multiple adaptive steps by fluorescein activated cell sorting (FACS); 3) Expand the applicability of heterophil adaptation to other gram-negative bacteria of importance to the poultry industry. Scientific advances over the life of the project: 1) The vaccine adaptation steps were increased to 11. Fecal shedding of vaccine and of challenge were very satisfactorily reduced. The vaccine strain was given at a dose of 10(8)CFU for three consecutive days by gavage. It was shed by 2 hens on the 3rd day

after vaccination, and by 1 hen on the 11th day after vaccination; 3) Fecal shedding of challenge ceased on the 9th day after challenge in the vaccinated group, and persisted for the 40-day duration after challenge in the challenge control group. 2) None of 525 eggs cultured after vaccination were infected. One egg isolation was made from 422 eggs in the vaccinated group after challenge. Of the 12 egg isolations in the challenge control group, 8 were egg shell (cloacal) isolates, and 4 were egg content isolates (transovarian). These limited data suggest the cloacal infection of eggs is the major risk factor. 3) A safe and effective live SE vaccine was developed in 1997. Many vaccines are effective in preventing disease, but few are also effective in preventing colonization and infection. The HASE TK 605 vaccine has met this stringent criterion. 4) It was shown that increasing the number of granulocyte (heterophil) passages from 6X to 11X has greatly improved the safety and effectiveness of the granulocyte adapted SE vaccine.

IMPACT: 1997/07 TO 2002/06

Salmonella enteritidis of poultry origin is the leading cause of foodborne illness in the U.S. and in the developed world. The HASE vaccine, developed earlier in this laboratory holds the promise of reduction (and perhaps elimination) of this source of foodborne disease. It is therefore important to know how this vaccine works.

PUBLICATIONS: 1997/07 TO 2002/06

1. Kramer, T., Reinke, C.R., and James, M. 1998. Reduction of fecal shedding and egg contamination of Salmonella enteritis by increasing the number of heterophil adaptations. Avian Dis 42:585:588.
2. Kramer, T.T. 1998. Effects of heterophil adaptation on Salmonella enteritidis fecal shedding and egg contamination. Avian Dis. 42:6-13.

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ACCESSION NO: 0187249 SUBFILE: CRIS

PROJ NO: TEX08815 AGENCY: CSREES TEX

PROJ TYPE: NRI COMPETITIVE GRANT PROJ STATUS: NEW

CONTRACT/GRANT/AGREEMENT NO: 2001-35201-09946 PROPOSAL NO: 2000-02614

START: 15 NOV 2000 TERM: 30 NOV 2002 GRANT YR: 2001

INVESTIGATOR: RICKE, S. C.

**PERFORMING INSTITUTION: POULTRY SCIENCE TEXAS A&M UNIV COLLEGE
STATION, TEXAS 77843**

MINIMIZING SALMONELLA enteritidis INVASION IN HENS DURING INDUCED MOLTING

OBJECTIVES: Determine if addition of dietary moderate zinc-low calcium will prevent colonization of *Salmonella* Enteritidis in the crop of chickens undergoing molting and what characteristics in the crop microenvironment are associated with this type of induced molt. Understand the potential role of the crop for *Salmonella* Enteritidis virulence expression while birds are undergoing molting and if key characteristics in the chicken crop microenvironment can be linked with limiting *S. Enteritidis* colonization and virulence expression.

APPROACH: The idea here is to compare the indigenous microbial response in crops of birds that have been molted either by feed deprivation or using a moderate Zn diet approach. The hypothesis is that feed intake will be retained in the birds molted via moderate Zn addition and the crop microflora will continue to be actively fermenting to the point of being inhibitory to *Salmonella* Enteritidis colonization and invasion. In addition to enumerating *Salmonella* Enteritidis recovered after infection in the different treatment groups we plan to quantitate fermentation products and enumerate crop lactobacilli. We will also examine virulence activity of *Salmonella* Enteritidis (h1A-lacZY transcriptional operon fusion) with a gene fusion strain for in vitro assays of crop contents.

NON-TECHNICAL SUMMARY: During the past 10-15 years, the number of cases of gastroenteritis due to *Salmonella enterica* subspecies *enterica* serovar Enteritidis (*S. Enteritidis*) infections has greatly increased in the U.S. and Europe and by 1995, *S. Enteritidis* comprised 25% of all foodborne *Salmonella* isolates. Between 1985 and 1991, over 80% of *S. Enteritidis* infections in the U.S. were associated with table eggs and this may be linked to the specific stressful management practice of inducing a molt to stimulate multiple egg-laying cycles in hens. Feed withdrawal is the primary method used in the layer industry to induce molting. However, feed withdrawal dramatically enhances *S. Enteritidis* recovery from crops, increases invasion of organs in chickens and increases horizontal transfer in flocks. The poultry industry needs alternative molting procedures that do not require feed withdrawal but allow managers to keep the economic advantages of recycling laying hens by molting without causing a *S. Enteritidis* contamination problem. In this proposal we plan to determine whether molt induction diets will minimize *S. Enteritidis* and if key characteristics in the chicken crop microenvironment can be linked with limiting *S. Enteritidis* colonization and pathogenesis.

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Termination Year 2001

ACCESSION NO: 0400561 SUBFILE: CRIS
PROJ NO: 6612-32000-017-00D AGENCY: ARS 6612
PROJ TYPE: USDA INHOUSE PROJ STATUS: TERMINATED
START: 16 APR 1996 TERM: 30 JAN 2001 FY: 2001

INVESTIGATOR: GAST R K; PETTER J G; MITCHELL B W; SWAYNE D E

PERFORMING INSTITUTION:
AGRICULTURAL RESEARCH SERVICE
ATHENS, GEORGIA 30613

PATHOGENESIS, DETECTION, AND CONTROL OF SALMONELLA ENTERITIDIS AND
OTHER SALMONELLAE IN CHICKENS

OBJECTIVES: Determine how Salmonella enteritidis (SE) spreads within and between poultry flocks and is deposited in eggs. Determine how phenotypic and genetic diversity influences invasion of host organs and egg contamination by SE. Identify environmental factors that influence the emergence of virulent forms of SE. Develop sensitive and specific diagnostic tests for SE in chickens and eggs. Develop effective SE vaccines. Develop methods to reduce surface and airborne dispersal of SE by dust reduction.

APPROACH: Chickens will be infected with SE by oral inoculation or exposure to environmental sources. Environmental factors and management practices that influence persistence and vertical or horizontal transmission of SE will be determined. Rapid and sensitive bacteriological and serological methods for detecting SE infection or contamination will be applied. Vaccine preparations will be tested for their efficacy. The pathogenic effects of SE phage types and strains will be compared. Chromosomal heterogeneity in virulence factor regulatory regions will be studied as it relates to egg contamination. The identity of protein and carbohydrate receptors that determine phage type will be established. Stages of the SE life cycle will be defined by coupling continuous cell culturing to analysis of cell surface protein and carbohydrate variability. Dust and bacterial counts will be measured in poultry production areas and techniques including ionization for reducing airborne dust and disease transmission will be evaluated. Athens, GA-SEPRL-main lab & bldg 3.11/4/99.

PROGRESS: 2000/10 TO 2001/09

1. What major problem or issue is being resolved and how are you resolving it? This project focuses on explaining the pathogenesis of Salmonella enteritidis (SE) infections in chickens and developing improved methods for prevention, detection, and control. Among the principal goals of the research are determining the processes and mechanisms by which SE infects chickens, spreads vertically and horizontally, and is deposited in eggs; assessing the influence of strain variations on the ability of SE to invade host organs and contaminate eggs; evaluating environmental factors that result in the

emergence of virulent forms of SE from avirulent populations; developing more sensitive and specific diagnostic tests for identifying SE infections of chickens and for detecting SE contamination of eggs; developing and evaluating effective killed and live vaccines for controlling SE infections in chickens and associated egg contamination; and developing electrostatic space charging technology to diminish the airborne spread of SE throughout poultry hatching and housing facilities.

2. How serious is the problem? Why does it matter? The association between human illness caused by SE and the consumption of contaminated poultry products is an important international public health and economic problem. In recent years, SE has been among the *Salmonella* serotypes most often reported to cause human illness. Eggs have been the most frequently implicated sources of human SE infections in the United States. As food-borne transmission of SE threatens both the safety of consumers and the ability of poultry producers to market their products, the formulation and implementation of effective control strategies for reducing the incidence of SE infections in chickens has been identified as an urgent priority by both government and industry.

3. How does it relate to the National Program(s) and National Component(s)? National Program 108, Food Safety (100%) This research contributes to the Microbial Pathogens component of the Food Safety National Program by providing scientists (veterinary, food, and agricultural), regulatory agency officials, and the poultry industry with urgently needed tools to understand, detect, and control SE infections of chickens.

4. What were the most significant accomplishments this past year? A. Single Most Significant Accomplishment during FY2000 year. No activity for this fiscal year. This project has been terminated and replaced by CRIS number 6612-32000-026. All activity is reported under that CRIS number. B. Other Significant Accomplishment(s), if any. No activity for this fiscal year. This project has been terminated and replaced by CRIS number 6612-32000-026. All activity is reported under that CRIS number.

5. Describe the major accomplishments over the life of the project including their predicted or actual impact. This project provided the first definitive experimental documentation that hens systemically infected with SE could produce internally contaminated eggs. Scientists found that SE infections can be highly persistent in both chicks and hens and elicit long-lasting antibody titers. The project developed and assessed the sensitivity and predictive value of methods for detecting specific antibodies in serum and egg yolks from infected hens. The project developed effective and practical bacteriological methods for consistently detecting very small numbers of SE contaminants in eggs. Efficient killed vaccines were developed and evaluated for reducing the susceptibility of laying hens to SE infection. Studies assessed the relationship between phage type of SE isolates and their virulence, infectivity, and invasiveness in chicks. One scientist determined that air movement can mediate the horizontal transmission of SE infection. An ESCS was developed under a CRADA to reduce airborne dust and microorganisms in hatching cabinets. The ESCS has been shown to have effectiveness comparable to a 95% media filter for removing dust in laboratory experiments in hatching cabinets and transmission cabinets and equal or better effectiveness for removing airborne bacteria and *Salmonella*. The ESCS reduced airborne SE in an isolation room with caged layers approximately 95%. The kill rate of the ESCS on airborne and surface SE at close range has been shown to be 98% or more. The ESCS has been patented and an exclusive license for poultry applications has been approved with BioIon, Inc. to manufacture and distribute the system.

6. What do you expect to accomplish, year by year, over the next 3 years? No activity for this fiscal year. This project has been terminated and replaced by CRIS number 6612-32000-026. All activity is reported under that CRIS number.

7. What science and/or

technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product? No activity for this fiscal year. This project has been terminated and replaced by CRIS number 6612-32000-026. All activity is reported under that CRIS number. 8. List your most important publications in the popular press (no abstracts) and presentations to non-scientific organizations and articles written about your work (NOTE: this does not replace your peer-reviewed publications which are listed below) No activity for this fiscal year. This project has been terminated and replaced by CRIS number 6612-32000-026. All activity is reported under that CRIS number.

PUBLICATIONS: 2000/10 TO 2001/09

No activity for this fiscal year. This project has been terminated and replaced by CRIS number 6612-32000-026. All activity is reported under that CRIS number.

ACCESSION NO: 0400984 SUBFILE: CRIS
PROJ NO: 6612-42000-022-00D AGENCY: ARS 6612
PROJ TYPE: USDA INHOUSE PROJ STATUS: TERMINATED
START: 01 DEC 1996 TERM: 30 JAN 2001 FY: 2001

INVESTIGATOR: HOLT P S; GAST R K; PETTER J G; SWAYNE D E; MITCHELL B W

PERFORMING INSTITUTION:
AGRICULTURAL RESEARCH SERVICE
ATHENS, GEORGIA 30613

EPIDEMIOLOGY AND ECOLOGY OF SALMONELLA ENTERITIDIS IN COMMERCIAL
POULTRY FLOCKS

OBJECTIVES: Identify the sources of introduction of Salmonella enteritidis (SE) and other salmonellae into commercial poultry flocks and the reservoirs where they persist in the poultry housing environment. Determine how SE spreads within and between commercial poultry flocks. Identify unique characteristics of Salmonella isolates, strains, serotypes, and phage types and apply this information to determine the epidemiological relationships between isolates from different sources.

APPROACH: Samples taken from diverse locations in commercial poultry housing facilities, and from the birds themselves, will be tested for S.enteritidis and other enteroinvasive salmonellae. Different sampling and testing methods will be selected or developed and then evaluated for their effectiveness in detecting SE. Samples will be obtained from flocks of different ages and housed using different management systems. Experiment- ally infected chickens will be used to establish or verify fundamental aspects of the host-pathogen relationship between SE and poultry. Statistical modeling tools will be applied to establish the significance of and relationships between individual

sources and reservoirs of salmonellae in commercial poultry flocks. Molecular analytical methods will be applied to characterize and differentiate *Salmonella* isolates.

PROGRESS: 2000/10 TO 2001/09

1. What major problem or issue is being resolved and how are you resolving it? *Salmonella enteritidis* (SE) is the causative agent of pandemic salmonellosis in people, which is most often acquired by consumption of contaminated eggs. The reservoir involved in transmission of SE to people is well identified, namely the egg-laying hen. It can be difficult to identify infected flocks, because they do not often become ill and because the organism can be difficult to detect in the hen-house environment even when the organs of birds are positive. It is also accepted that mice are important vectors for transmission of SE to hens. Thus, the basic biology of SE appears to have unique parameters as compared to what happens when other types of *Salmonella* are in the on-farm environment. This research program addresses how the biology and genetics of SE differs from that of other *Salmonella*.

2. How serious is the problem? Why does it matter? Increased illness in people from SE has existed for at least 20 years and it is currently the most prevalent serotype causing salmonellosis in the world and the second most prevalent in the U.S. The concern is that the incidence of illness in the U.S. from SE has the potential to increase to levels seen in Western Europe and other countries.

3. How does it relate to the National Program(s) and National Component(s)? This project is in the Microbial Pathogens component of National Program 108, Food Safety (100%). The research evaluates how the biology and genetics of SE can be used to halt its growth and survival in chickens and in the hen house, because these links in the infection route to humans precede egg contamination.

4. What were the most significant accomplishments this past year?

A. Single Most Significant Accomplishment during FY 2001 year: SE had been thought to be a single clone with minimal difference between isolates from different geographic regions. This project studied surface carbohydrate variation of SE, especially from mice in chicken houses, and showed that SE has a significantly more variable cell surface than did *Salmonella typhimurium*, which is another important cause of human illness not associated with egg contamination. These findings supported the concept that the house mouse plays a unique role in the pandemic associated with SE.

B. Other Significant Accomplishment(s), if any: The genetic basis for why SE is infectious was poorly understood. A series of infection studies were conducted that revealed that loss of a molecule called flagella enhances the ability of SE to be infectious when given by mouth. This information may indicate that vaccines directed against the flagella may prevent SE infections.

5. Describe the major accomplishments over the life of the project including their predicted or actual impact. This research identified that it is possible to use the structure of the lipopolysaccharide molecule of SE and other *Salmonella* serotypes to conduct epidemiological investigations of how strain heterogeneity potentially contributes to emerging patterns of salmonellosis in people and animals. The outcome of this research is improved epidemiological methods for monitoring emergence of SE and other potential pathogens on-farm by increasing knowledge of how bacteria can change to cause sustained illness in people through the food supply.

6. What do you expect to accomplish, year by year, over the next 3 years? This project was terminated.

7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product? The science and technology of how

to assess strain heterogeneity of SE has been transmitted to epidemiologists, infectious disease experts, and public health officials through publications broadly available in peer-reviewed journals. It is being made available to farmers and industry through vaccine studies funded by CRADAS that will deliver improved products to market. One aspect of the science has been made available to industry by patenting. The technology is durable, because the general knowledge about how to grow and analyze SE can be applied to other bacteria. 8. List your most important publications in the popular press (no abstracts) and presentations to non-scientific organizations and articles written about your work (NOTE: this does not replace your peer-reviewed publications which are listed below) No activity during FY2001

PUBLICATIONS: 2000/10 TO 2001/09

Parker,C.T., Liebana,E., Henzler,D.J., Guard-Petter,J. Lipopolysaccharide O-chain microheterogeneity of Salmonella serotypes Enteritidis and Typhimurium. Environmental Microbiology. 2001. V.5.p.332-342.

ACCESSION NO: 0404088 SUBFILE: CRIS

PROJ NO: 6612-42000-036-00D AGENCY: ARS 6612

PROJ TYPE: USDA INHOUSE PROJ STATUS: NEW

START: 31 JAN 2001 TERM: 30 JUN 2001

INVESTIGATOR: HOLT P S; VACANT; SWAYNE D E

PERFORMING INSTITUTION: AGRICULTURAL RESEARCH SERVICE ATHENS, GEORGIA 30613

EVALUATION OF STRATEGIES FOR INDUCED MOLTING ON SALMONELLA ENTERITIDIS PROBLEMS IN LAYING FLOCKS

OBJECTIVES: Define the physiological, neuroendocrinological and psychological alterations that occur in the hen during feed withdrawal to induce molt vs. alternative molt procedures. Evaluate whether experimental observation of molt effects on Salmonella enteritidis infection also occur under commercial conditions. Evaluate whether alternative molt procedures can reduce or eliminate the Salmonella enteritidis problem normally observed during an experimental molt.

APPROACH: Examine Salmonella enteritidis situation in commercial operations at various times pre, during and post molt. Develop molting procedures alternative to feed withdrawal such as low energy feeds or hormone therapy which do not cause exacerbated Salmonella enteritidis infection. Examine the effects of molting on hormone levels in brain, serum, and gut and the impact of molting on intestinal integrity. Examine effect of molting on reproductive tract function and morphology.

PROGRESS: 2000/10 TO 2001/09

1. What major problem or issue is being resolved and how are you resolving it? Induced molting is

an important management tool used by 70-80% of the layer industry to achieve a second egg lay from aging hens (an estimated 168-192 million hens are molted annually). Previous experimental studies showed that molting via long term feed removal dramatically increased problems with *Salmonella enterica* serotype Enteritidis (SE). Because of the studies, molting has come under increased scrutiny by federal regulatory agencies and animal welfare groups as a potential food safety issue. Information is still too limited to determine the legitimacy of such claims and the current project will provide additional information by determining whether molting in a commercial setting similarly increases SE problems, examining alternative molting procedures with respect to their effects on SE infection, studying intervention strategies such as vaccination to ameliorate the problem, investigating in detail the degree of stress in birds subjected to molt and whether alternative molt procedures are less stressful, and studying the physiological effects of molting to determine potential causes of the exacerbated infection observed in the hens during molt.

2. How serious is the problem? Why does it matter? Eggs produced by molted hens may be a food safety risk to the consuming public. It is estimated that fully a third of the profits derived from a flock during its life span comes from molted hens. The producer could lose this very important management tool unless studies are conducted to assess the problem, develop intervention strategies to reduce the problem, and generate new methods to recycle flocks.

3. How does it relate to the National Program(s) and National Component(s)? This project is in the National Programs 108 on Food Safety (75%) and 103 on Animal Health (25%). In Food Safety, developing alternatives to molting of laying hens that will prolong their productive egg laying and not be conducive to SE infection supports the Microbial Pathogens Component. In addition, the project's objectives and goals are aligned with the President's Council on Food Safety 1999 Action Plan document that directs further research to provide data on molting to federal action agencies that will support regulation of industry practices based on logical, science-based information. In Animal Health, the stress component of the studies addresses Disease Control Strategies and Host/Pathogen Interactions components.

4. What were the most significant accomplishments this past year? A. Single most significant accomplishment during FY 2001? This was a temporary bridging CRIS, please see progress reported under project 6612-32000-031-00D. NPS changed the project number. B. Other significant accomplishment(s), if any. Please see accomplishments listed under project 6612-32000-031-00D. C. Significant accomplishments/activities that support special target populations. Please see accomplishments/activities noted under project 6612-32000-031-00D. D. Progress Report. This was a temporary 3 month bridging CRIS for the final CRIS number 6612-32000-031-00D. All progress is reported under 6612-32000-031-00D.

5. Describe the major accomplishments over the life of the project including their predicted or actual impact. This was a 3 month temporary bridging CRIS. Previous accomplishments of the CRIS dealing with molting include - 1) molting depressed cell-mediated immunity in hens; 2) molting increased the severity of SE infections in hens; 3) molting made the hens 1,000-10,000-fold more susceptible to an SE infection which resulted in the rapid transmission SE to uninfected, but exposed, molted hens. As a result of these studies, the USDA/FSIS *Salmonella enteritidis* Risk Assessment Team, in their 1998 Risk Assessment document, placed molting as a central flock variable for increasing the risk of eggs produced which contain SE. 4) developed alternative molting procedure using wheat middlings which dramatically decreased SE levels in hens. As a result of these studies, researchers have moved to field studies to examine the economic utility of using wheat middlings in a commercial situation.

6. What do you

expect to accomplish, year by year, over the next 3 years? This project was a 3 month temporary bridging project and is terminated. 7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product? This project number was changed by NPS to 6612-32000-031-00D. Project now terminated. 8. List your most important publications in the popular press (no abstracts) and presentations to non-scientific organizations and articles written about your work (NOTE: this does not replace your peer-reviewed publications which are listed below) See project 6612-32000-031-00D.

PUBLICATIONS: 2000/10 TO 2001/09

No publications reported this period.

ACCESSION NO: 0178904 SUBFILE: CRIS
PROJ NO: IOWV-405-25-09 AGENCY: CSVM IOWV
PROJ TYPE: STATE PROJ STATUS: TERMINATED
START: 09 MAR 1998 TERM: 31 MAR 2001 FY: 2000

INVESTIGATOR: KRAMER, T. T.; HARRIS, R. S.

PERFORMING INSTITUTION:
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IOWA STATE UNIVERSITY
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AMES, IOWA 50011

A LIVE SALMONELLA ENTERITIDIS (SE) VACCINE AGAINST EGG TRANSMITTED SALMONELLOSIS

OBJECTIVES: Salmonella enteritidis (SE) is the most common source of food poisoning worldwide. The primary source of SE contaminated food is the chicken egg. The objective of this research is to validate the safety for humans, and to explore the marketability of a live, heterophil attenuated Salmonella enteritidis (HASE) vaccine for the prevention of egg-transmitted salmonellosis.

APPROACH: Selection of live vaccine candidates by heterophil adaptation.

PROGRESS: 1998/03 TO 2001/03

Fecal shedding and egg transmission of a heterophil attenuated, vaccine candidate strain of Salmonella enteritidis (SE) was evaluated in laying hens. Fecal shedding and egg transmission of vaccine and challenge SE were used to assess, safety and efficacy of the heterophil attenuated SE. Fecal shedding was very significantly reduced in vaccinated hens by comparison to challenge

controls ($p < 0.001$). None of 1,019 eggs cultured from vaccinated and challenged hens were infected with SE. Twelve of 479 (2.5%) of control eggs were infected

IMPACT: 1998/03 TO 2001/03

Further evidence was obtained for the suitability of heterophil adapted *Salmonella enteritidis* as a live attenuated vaccine against salmonellosis of poultry.

PUBLICATIONS: 1998/03 TO 2001/03

No publications reported this period

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ACCESSION NO: 0178167 SUBFILE: CRIS

PROJ NO: IOWV-416-23-73 AGENCY: CSREES IOWV

PROJ TYPE: NRI COMPETITIVE GRANT PROJ STATUS: TERMINATED

CONTRACT/GRANT/AGREEMENT NO: 97-35201-4608

START: 01 SEP 1997 TERM: 31 AUG 2001 FY: 2000 GRANT YR: 1997

INVESTIGATOR: MINION, F. C.; TRAMPEL, D. W.

PERFORMING INSTITUTION:

VETERINARY MEDICINE

IOWA STATE UNIVERSITY

S. AND 16TH ELWOOD

AMES, IOWA 50011

SALMONELLA ENTERITIDIS HETEROPHIL RESISTANCE

OBJECTIVES: 9702755. Obtain a better understanding of *Salmonella enteritidis*-chicken interactions at the molecular level. This will be accomplished using unique mutants that are resistant to chicken heterophil killing and by completing the following specific aims: 1) We will complete the assessment of the SE mutants in chicken in order to assess their pattern of colonization of infected tissues and affinity for egg laying tissues; 2) Genes involved in immune cell resistance will be identified by screening complemented strains in cell cultures; 3) Mutations will be constructed in these genes in the wild type strain in order to confirm their role in immune cell resistance; 4) Mutants will be assessed for virulence and egg transmissibility in chickens. For unknown reasons, immune cell resistance is directly linked to lowered virulence in SE. These studies will shed light on

the possible mechanisms involved and add to our understanding of salmonella pathogenesis.

APPROACH: First develop mutant strains expressing green fluorescent protein to enhance our ability to follow *S. enteritidis* in host tissues and eggs. These strains will then be used to infect chickens and bacteriological and histopathological studies undertaken. Cosmid libraries of wild type *S. enteritidis* will be constructed and used to complement the mutant strains. Complementing clones with wild type phenotype will then be analyzed by subcloning and transposon mutagenesis, and the genes involved in heterophil resistance (*htr*) sequenced and analyzed. Knockout mutations in putative *htr* genes will be constructed in wild type strains, and the resulting strains analyzed for sensitivity in heterophil cultures.

PROGRESS: 1997/09 TO 2001/08

The overall goal of this proposal was to determine the genetic basis for heterophile resistance of a *Salmonella enteritidis* (SE) mutant (TK605) and to characterize this mutant in terms of its persistence and vaccine potential. The latter aim was accomplished in the first two years of the grant. A third aim was to develop green fluorescent protein (GFP) producing strains of SE strain TK474 and follow their transmission through the chicken to learn more about the cell types and tissue locations for SE during persistence. After integrating the GFPuv structural gene downstream of the *lac* promoter in the chromosome, colonies were unexpectedly fluorescently unstable in their fluorescence after in vitro passage. We then obtained another derivative of GFP on a R6 vector used in *Salmonella typhimurium* studies, which was stable in SE after prolonged passage in vitro. Studies of this construct in SE in mature hens showed that the numbers of fluorescent salmonella in tissues was low, making it difficult to follow the organism in specific tissues, and we did not pursue this avenue further. To determine the genetic basis for heterophile adaption, we sought to complement the mutations in SE strain TK605 using cosmid based approaches. The differences in survival between the mutant and wild type strains in chicken heterophile cultures, however, were not great enough to allow direct selection for a complemented mutant strain. Instead, we focused the last 18 months on invasion studies and signature tagged mutagenesis (STM) to identify genes needed for SE cell invasion with the hypothesis that invasion is critical for heterophile survival, tissue dissemination and persistence in the reproductive tract. STM invasion negative mutants were identified using Vero cell cultures. Assays using MTT or XTT to quantify the number of *Salmonella* present after lysis of the Vero cells had high background and variability. Invasion was then assessed by a growth/no-growth assay on brilliant green agar plates containing kanamycin, which led to the identification of 46 invasion-negative mutants. These mutants were then tested in a day-old chick model for virulence. The livers of all birds were sampled for *Salmonella* mutants using brilliant green agar plates with kanamycin. Virulence varied among the invasion-negative mutants with some low pathogenicity and some retaining high virulence, rapidly killing all chicks in a group. Further, STM experiments were also performed, and the mutants displayed variability in their ability to persist in chickens in comparison to wild type salmonella. Identification of the STM mini-transposon insertion site by DNA sequencing is currently in progress. Direct cloning of the transposon and flanking sequences, and direct sequencing of chromosomal DNA had little success. The most successful method for obtaining junction site sequences was using inverse PCR. The insertion site for eleven of the forty-six mutants has been identified. At the conclusion of this stage, we will have

identified different loci in SE involved in Vero cell invasion and correlated that phenotype with persistence in mature chickens and virulence in a day-old chick model.

IMPACT: 1997/09 TO 2001/08

Salmonella enteritidis remains an important world-wide food safety pathogen. Identification of genes involved in tissue invasion and the correlation of specific genes with virulence and persistence in chickens will provide important information needed for a better understanding of the pathogenic mechanisms of this organism. These genes might also provide therapeutic targets for development of better intervention strategies both at the pre-harvest and post-harvest stages.

PUBLICATIONS: 1997/09 TO 2001/08

1. Kramer, T. T. 1998. Effects of heterophil adaption on Salmonella enteritidis fecal shedding and egg contamination. Avian Dis. 42:6-13.
2. Kramer, T.T., C. R. Reinke, and M. James. 1998. Reduction of fecal shedding and egg contamination of Salmonella enteritidis by increasing the number of heterophil adaptations. Avian Dis. 42:585-588.
3. Kramer, T.T. and J. Vote. 2000. Granulocyte selected live Salmonella enteritidis vaccine is species specific. Vaccine 18:2239-2243.

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ACCESSION NO: 0400221 SUBFILE: CRIS
PROJ NO: 6612-32000-019-00D AGENCY: ARS 6612
PROJ TYPE: USDA INHOUSE PROJ STATUS: NEW
START: 09 APR 1996 TERM: 08 APR 2001 FY: 2000

INVESTIGATOR: TUMPEY T; MITCHELL B W; HOLT P S; SWAYNE D E

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STIMULATION OF MUCOSAL IMMUNITY IN CHICKENS TO PROTECT AGAINST ENTERIC AND RESPIRATORY PATHOGENS

OBJECTIVES: Examine the development of local humoral immune response at mucosal surfaces in chickens and compare this response with systemic immunity. Develop vaccines for mucosal immunity against intestinal and respiratory pathogens in poultry and diagnostic tests that will predict

effectiveness. Determine the mechanisms for generation of airborne pathogens. Develop controls to improve poultry health and enhance mucosal vaccine effectiveness by reducing airborne pathogens and dust.

APPROACH: Birds will be orally infected with salmonella enteritidis (SE) and serum and intestinal anti-SE antibody levels will be ascertained over time. The birds will be re-infected to determine the development of serum and intestinal immunological memory. Immune recognition of different components of SE in serum and the intestinal tract will be compared. The protective role of serum and mucosal antibodies will be ascertained by passive administration of antibodies to naive birds and following the progression of the infection. The development of immunity in the intestinal tract will be delineated by immunoassay of intestinal contents and elispot analysis of purified lamina propria lymphocytes. Dust and bacterial counts will be measured in hatching cabinets and other poultry production areas. Dust reduction techniques studied will include lowering air velocity and using an electrostatic space charge with a grounded collection system. Experiments will be conducted to characterize airborne transmission of SE and to explore treatments for reducing it.

PROGRESS: 1999/01 TO 1999/09

1. What major problem or issue is being resolved and how are you resolving it? Pathogens such as *Salmonella enteritidis* (SE), avian influenza virus, and Newcastle disease virus initiate their infections at mucosal surfaces such as the intestinal or respiratory tract. Procedures which protect these sites from infection, either by inducing active immunity or by reducing the challenge dose reaching the animal would significantly reduce the morbidity, mortality, and egg contamination resulting from infection. Vaccination regimens against these infections generally involve parenteral injections which induce a good systemic immune response. While this regimen does evoke a certain degree of protection at mucosal surfaces, it is not complete - a certain percentage of the birds remain infected and continue to shed organism into the environment and, in the case of SE, produce eggs contaminated with the organism. This scenario is observed regularly in the field and, as a result, vaccination against avian influenza virus is not performed in chickens in this country and only moderate vaccination against SE occurs. Recent serious outbreaks of highly pathogenic avian influenza in poultry in Mexico and in Hong Kong underscore the need for improved vaccination regimens to combat this problem organism. The continuing problem of SE infections in humans traced to contaminated eggs and the limited use by industry of currently available vaccines indicates the need for newer and better immunization methods to prevent infections. If immunity were to be elicited via mucosal vaccination at the site where infection was initiated, there would be a greater chance of stopping the organism before it has a chance to become firmly established within the tissue. Our laboratory is taking a multiple-prong attack at this problem by examining development of immunity at mucosal surfaces following infection and comparing this response with that in serum. We are also developing vaccination regimens which activate protective immunity at these surfaces. A third area of research is the use of procedures to reduce the levels of the pathogen in the air environment and therefore reduce the challenge dose reaching the bird.

2. How serious is the problem? Why does it matter? With highly pathogenic avian influenza virus, the situation is grave and the primary remedy is massive flock slaughter and quarantine of poultry products leaving the area, both of which put a severe financial burden on the producer, the region, and the industry as a

whole. For SE, the situation is very serious. This organism is the leading *Salmonella* serovar causing human food borne infections in the U.S. and, while the number of outbreaks of food borne infections by this organism is decreasing, the number of sporadic cases continues to increase. The significance of this is two-fold: 1) a large number of individuals are becoming ill, and some die, due to consumption of eggs contaminated with this organism; 2) this has dramatic repercussions on the egg industry due to reduced egg consumption and the involvement of regulatory agencies in diverting eggs to pasteurization. 3. How does it relate to the National Program(s) and National Component(s) to which it has been assigned? National Program 103, Animal Health (75%) National Program 108, Animal Health (25%) Because of the disastrous nature of poultry infections by avian influenza virus and Newcastle disease virus, regimens which prevent the initiation and dissemination of the organisms within flocks fit well within the National Program animal health mandate. Similarly, food safety is a major component of the National Program agenda and intervention strategies which help prevent the dissemination of a human disease organism within flocks and block the entry of the organism into the human food chain are important areas of investigation. 4. What were the most significant accomplishments this past year? Studies were conducted with an electrostatic space charge system in a caged layer room to determine dust reduction capabilities and potential of the system for reducing airborne *Salmonella enteritidis*. Duplicated experiments in a caged layer room with artificially and naturally generated dust indicated that electrostatic space charge system treatment reduced dust concentration by 52-91%. Reductions in dust level of 50% reduce airborne bacterial counts by 100 fold or more. A prototype electrostatic space charge system that included an automatic rinse system was developed and installed in several commercial chicken hatcheries. The system reduced dust by 82% and *Salmonella* positive cabinets by as much as 83%. Hatchability with the system improved an average of 2.7%. The electrostatic space charge system will decrease transmission of disease-causing organisms and improve food safety. One-2 day-old chicks were unable to mount a significant antibody response in either the serum or intestinal tract. In adult chickens, a strong systemic and intestinal response to SE occurred within a week post challenge and the chickens cleared the infection within several weeks. These results demonstrated that the age when birds are exposed to infection is a very important variable with regards to their ability to respond to challenge and also possibly to vaccination. An ELISPOT assay was developed to detect specific antibody producing cells in the spleen and cecal tonsil in birds either infected or vaccinated against SE. This assay will assess the role of different intestinal tissues in the elicitation of an intestinal immune response. Determined that certain compounds added to *Salmonella enteritidis* killed vaccine emulsions resulted in an enhanced serum and mucosal antibody response to the SE immunogen. This will improve vaccines for use in SE control. 5. Describe the major accomplishments over the life of the project including their predicted or actual impact. This a new CRIS, in its third year, so a large proportion of the information was presented in Question 4. However, we found that chicks infected with SE at 1-2 days post hatch cannot clear the infection and remain persistently infected for over 20 weeks. Serum and mucosal responses in these birds were severely depressed, with many birds not having any detectable SE-specific antibodies. When these individuals were vaccinated or re-infected, they were only minimally able to respond immunologically to the new stimulus, indicating that very little immunological memory occurred. These studies point to the hatchery as a very important area to prevent SE infection since challenge at this age can have serious repercussions on the health of the chicks. In the previous CRIS we

examined the effect of stress on immunity in poultry and there were numerous accomplishments. We found that induced molting, a procedure used by 70% of the layer industry to achieve a second egg lay from aging flocks (affecting approximately 140-166 million hens annually) depressed the immunity in the birds and substantially increased the severity of, susceptibility to, and transmission of SE infections. Airborne transmission of SE, not normally a route of spread of SE, was also observed in molted hens indicating that the procedure could substantially affect the spread of the organism through a flock. As a result of this work, molting was identified by USDA/APHIS as a major risk factor for the production of eggs contaminated with SE. 6. What do you expect to accomplish, year by year, over the next 3 years? Develop ELISPOT assays to further delineate the immune response in various locations in the intestinal tract to identify the most important areas for targeting vaccines. Determine whether the cecal tonsil is an important organ for the development of an intestinal immune response. Evaluate more compounds with respect to their adjuvanticity in the intestinal tract and examine whether these vaccines can be adapted for use in ovo vaccination protocols. 7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product? A patent application is pending for the electrostatic space charge system technology and three license applications have been received for manufacture of the system. Working under a CRADA with a manufacturer, we developed a panel system, using monoclonal specific for SE flagella developed in our laboratory, for detecting SE in poultry samples within 15 minutes. A Small Business Innovative Research grant was awarded by USDA to further evaluate the capabilities of the panel in depth. 8. List your most important non-peer reviewed publications and presentations to non-scientific organizations, and articles written about your work (NOTE: this does not replace your peer reviewed publications which are listed below). HOLT, P.S. Induced molting and possible Salmonella enteritidis problems in layer flocks. Foodonics Incorporated Egg Quality Assurance Producer's Meeting, Blackshear, GA, 1999. HOLT, P.S. Induced molting and possible Salmonella enteritidis problems in layer flocks. Southeastern Egg Producers Conference, Tallahassee, FL, 1999. HOLT, P.S. Risk factors for a Salmonella enteritidis infection. SE Research Forum, Atlanta, GA, 1999 sponsored by the United Egg Producers.

PUBLICATIONS: 1999/01 TO 1999/09

1. HOLT, P.S., MITCHELL, B.W., SEO, K-H., and GAST, R.K. 1999. Use of negative air ionization for reducing airborne levels of Salmonella enterica serovar Enteritidis ... Journal of Applied Poultry Research, in press.
2. DODSON, S.V., MAURER, J.J., HOLT, P.S., and LEE, M.D. 1999. Temporal changes in the population genetics of Salmonella pullorum. Avian Diseases 43, in press.
3. HOLT, P.S., GAST, R.K., ... 1999. Hyporesponsiveness of the systemic and mucosal humoral immune systems in chickens infected with Salmonella at one day of age. Poultry Science, in press.
4. CHAUBAL, L.H. and HOLT, P.S. 1999. Characterization of motility and identification of flagella proteins in the avian pathogen Salmonella pullorum. American Journal of Veterinary Research, in press.
5. MITCHELL, B.W. 1999. Electrostatic space charge system for dust and pathogen removal in commercial hatching cabinets. Poultry Science 78(S1):143.

6. MITCHELL, B.W. 1999. Performance of an electrostatic dust reduction system in a commercial hatchery. Dust Control in Animal Production Facilities International Symposium, CIGR EurAgEng, Jutland, Denmark.
7. HOLT, P.S., MITCHELL, B.W., SEO, K.-H., and GAST, R.K. 1999. Use of negative air ionization for reducing airborne levels of Salmonella Enteritidis in a room. Proc. Western Poultry Disease Conference, page 31.
8. HOLT, P.S., GAST, R.K., STONE, H.D.. 1999. Infection of chicks with Salmonella enteritidis at one day of age results in persistent infection and hyporesponsiveness humoral immune system. Immunology Letters 69:65.
9. HOLT, P.S. 1999. Possible application of the alpha-1 acid glycoprotein assay as an indicator of stress during an induced molt. Poultry Science 78(S1):29.

Termination Year 2000

ACCESSION NO: 0178835 SUBFILE: CRIS
PROJ NO: ILLU-35-0226 AGENCY: SAES ILLU
PROJ TYPE: STATE PROJ STATUS: TERMINATED
START: 01 AUG 1998 TERM: 31 JUL 2000 FY: 2000

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DEVELOPMENT OF SALMONELLA VACCINES FOR CHICKENS

OBJECTIVES: C-FAR 1999 Internal. Salmonella enteritidis is a pathogenic bacteria responsible for most cases of human food poisoning acquired from eating chickens or eggs. Because this bacterium does not usually cause symptoms in chickens, it is difficult to detect contaminated flocks. The long term aim of this project is to design a vaccine against S. enteritidis that can be easily administered to young chicks to protect chickens and their eggs from infection.

APPROACH: Virulence factors that have formed the basis of other vaccines include fimbriae, long proteinaceous molecules on the bacterial surface. The SEF fimbriae are unique to S. enteritidis virulence and seem to play a pivotal role in the ability of this particular bacteria to infect chickens and eggs. Therefore, we will use a molecular genetic approach to characterize the role of SEF fimbriae in virulence and to test the role of SEF fimbriae as a protective immunogen.

PROGRESS: 1998/08 TO 2000/07

C-FAR 1999 Internal. The objective was to design an effective, inexpensive vaccine against *Salmonella enterica* sv. enteritidis that can be administered to young chicks to protect chickens and their eggs from infection. Preliminary studies suggested that a type of fimbriae restricted to enteritidis may provide a useful vaccine target. Fimbriae are long, proteinaceous structures that extend from bacterial cells and mediate attachment to specific surfaces. Fimbriae have been shown to be critical virulence factors in enteric bacteria and play multiple roles in the course of infection. *Salmonella* infections are initiated by adherence to intestinal epithelium using multiple fimbriae. Fimbriae involved in this common step of *Salmonella* infections are found in all *Salmonella* serovars. Enteritidis also produce a unique fimbriae encoded by the *sef* genes (*Salmonella* Enteritidis fimbriae). SEF are not found in *S. Typhimurium* or more distantly related *Salmonella* serovars, but all Enteritidis isolates express SEF fimbriae. Results implicated SEF as a unique virulence factor for Enteritidis. Immunization of mice with purified SEF protects mice from Enteritidis infection, indicating that SEF are expressed in the host and elicit a strong immune response. Properties of these fimbriae suggest that this may be a novel vaccine target. We showed that mutations in *sef* reduce virulence of Enteritidis in mice by 10⁴-fold and 10⁵-fold. In contrast, mutations in *sef* increase virulence in chickens, suggesting that these fimbriae may play an important role in establishment of chronic, asymptomatic infections in chickens. We have characterized Enteritidis infections in chickens to develop a model system for subsequent characterization of disease. Our research showed that day old Leghorn chicks are susceptible to Enteritidis infections and a dose of 10⁴-fold bacteria is lethal to young chicks. At lower doses, Enteritidis colonizes the ceca, cloaca, liver, spleen and reproductive tissue of chicks. Older chickens effectively clear the infection. Competition experiments between the *sefA* mutant and wild-type Enteritidis confirm that loss of SEF results in increased virulence in chickens. A simple explanation of these results may be that SEF acts as an effective immunogen, stimulating an protective cell-mediated immune response. This would enhance the clearance of the wild-type strain while allowing a mutant lacking SEF to persist in higher numbers. This conclusion is supported by previous studies indicating that SEF induces a strong T-lymphocyte response. Why would SEF promote virulence in mice and decrease virulence in chickens? In BALB/c mice, SEF promotes uptake of Enteritidis into macrophages which may limit the direct exposure of this potential antigen to the host immune system. These results imply that SEF may play different roles in the pathogenesis of Enteritidis depending on the host. To test the effectiveness of SEF as a vaccine, we developed methods to overproduce and purify SEF protein and we plan to use this protein to immunize chickens. The immunized chickens will be subsequently tested for protection against Enteritidis infections.

IMPACT: 1998/08 TO 2000/07

Salmonella enteritidis infects a wide variety of animals, including chickens and humans. enteritidis typically initiates an infection through the fecal oral route where it colonizes the intestinal wall and causes diarrhea. In adult chickens these infections are usually asymptomatic, but seemingly healthy chickens can carry and shed enteritidis for long periods of time after the initial infection. enteritidis can also colonize the developing egg in an otherwise asymptomatic chicken, making enteritidis infections very insidious. Recently, the occurrence of enteritidis infections in humans has increased dramatically, largely due to the consumption of infected chicken eggs. Despite the impact of enteritidis infections on agriculture and human health, the virulence determinants (i.e., the

mechanisms responsible for causing disease) that mediate the unique aspects of enteritidis infections in chickens are poorly understood. Understanding the unique virulence mechanisms of enteritidis may lead to new, better ways of preventing infections in chickens and thereby alleviating this major source of food poisoning. Although enteritidis is the principle causes of Salmonella food poisoning, most research on Salmonella pathogenesis has focused on Salmonella Typhimurium. Work in many labs is beginning to elucidate the Typhimurium virulence determinants. Our work identified a virulence factor that is unique to Salmonella Enteritidis which has potential for use as a cheap, effective vaccine for chickens.

PUBLICATIONS: 1998/08 TO 2000/07

1. Edwards, R., Schifferli, D. and Maloy, S. 2000. A novel role for Salmonella enteritidis fimbriae in resistance to macrophage killing. *Proc. Natl. Acad. Sci. USA* 97: 1258-1262.
2. Edwards, R. and Maloy, S. 2001. Inside or outside: Detecting the cellular location of Salmonella during infection. *Biotechniques* 30: 304-311.
3. Townsend, S. 2001. Salmonella enterica serotype Typhi possesses a unique repertoire of fimbrial genes. *Infect. and Immun.* 69 (In Press).
4. Edwards, R., Matlock, B., Heffernan, B. and Maloy, S. 2001. Regulation of SEF fimbriae expression in Salmonella enteritidis (Submitted).
5. Helm, R.A., Sanderson, S. and Maloy, S. 2001. A rapid approach to determine the *rrn* arrangement in Salmonella serovars (Submitted).
6. Matlock, B., Heffernan, B., Edwards, R., Bahr, J. and Maloy, S. 2001. The role of SEF14 fimbriae in the pathogenesis of Salmonella enteritidis in day-old chicks (In Preparation).

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ACCESSION NO: 0149377 SUBFILE: CRIS
PROJ NO: 6406-32000-005-00D AGENCY: ARS 6406
PROJ TYPE: USDA INHOUSE PROJ STATUS: NEW
START: 21 MAR 1995 TERM: 20 MAR 2000 FY: 2000

INVESTIGATOR: BRANTON S L; BEARSON S M; LOTT B D; SIMMONS J D

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DIAGNOSIS AND CONTROL OF MYCOPLASMOSIS IN POULTRY

OBJECTIVES: Improve both the diagnosis and identification of *Mycoplasma synoviae* (MS) and *Mycoplasma gallisepticum* (MG) using an antigen-based ELISA and selected monoclonal antibodies. Strain specificity will be pursued for MG. Determine effects of common poultry mycoplasmal commensals on serology and egg quality. Determine effects of commercially available live MG vaccines on layer chickens. Isolate the receptor gene(s) from F strain *Mycoplasma gallisepticum* and insert them into *Mycoplasma gallinarum*.

APPROACH: Commercial hens maintained in fiberglass isolation units will provide both production and egg quality data. They will further serve as both the sera and culture source for use in selecting from currently existing monoclonal antibodies which will be used to produce the antigen-based ELISA. BALB/c mice will be purchased and used to produce other needed monoclonal antibodies which will be screened and selected against both direct hen mycoplasmal isolates and against multiple-passaged mycoplasmal cultures. Selection should result in a bank of monoclonals having specificity towards mycoplasmal-common, species-specific as well as strain-specific epitopes. The antigen-based ELISA will be utilized to determine the contribution of common avian mycoplasmal commensals on MG and MS serology. Using molecular approaches, a non-pathogenic, life-long protective immunity to respiratory disease caused by *Mycoplasma gallisepticum* will be developed.

PROGRESS: 1999/01 TO 1999/09

1. What major problem or issue is being resolved and how are you resolving it? The objectives of this research are: a) to improve the diagnosis and identification of *Mycoplasma gallisepticum* (MG) and *Mycoplasma synoviae* (MS), b) to identify virulence factors that enable F strain MG to displace S6 strain MG, c) to characterize the effects of the three currently available live MG vaccines on egg production, egg and eggshell quality parameters, d) to characterize the antibody responses of infected poultry to mycoplasma antigens by using monoclonal antibodies and molecular techniques, and e) to evaluate the impact of *Mycoplasma* infection in poultry. 2. How serious is the problem? Why does it matter? Fully 80% of commercial egg laying chickens are believed infected with *Mycoplasma gallisepticum* (MG) which results in decreased egg production, increased pharmaceutical costs, and mortality. MG infection of broiler breeders is sporadic and results in either condemnation and slaughter of infected hens and/or infection of progeny which in turn, results in increased mortality, feed costs and slaughter house condemnation. "Backyard" flocks exist as primary reservoirs of infection. Numerous other species of *Mycoplasma* have been found in commercial poultry. Fully 20% of the approximately 125 known mycoplasmas can be found in the class Aves and of these about one-half (12) are found in poultry. Of these 12, only four have been investigated to any depth. At least five of the 12 mycoplasmas found in poultry can be isolated in commercial layer chickens. We do not know the effect(s) of these other mycoplasmal species on poultry and, coupled with the fact that mycoplasmal infections in poultry are not cleared with antibiotics (once infected, a chicken remains infected for the duration of its life) mycoplasmal infection presents a dread scenario for the poultry industry. 3. How does it relate to the National Program(s) and National Component(s) to which it has been assigned? This research is assigned to National Program 103 Animal Diseases. It is appropriate for the sections on "pathogen detection," "epidemiology of disease," and "disease prevention/control through vaccine and novel strategies." 4. What were the most significant accomplishments this past year? Although the temperature sensitive (ts-11) live vaccine strain of MG

has been available for use in commercial layers for the past nine years, there has been NO information available to the producer concerning the vaccine's effects on egg production, egg weight distribution, egg weight, blood/meat spot incidence, pimpling incidence, Haugh unit determination and eggshell strength despite the fact that the vaccine was developed to reduce egg production losses associated with MG infection. The research included measuring, recording and analysis of the aforementioned parameters together with hen mortality was conducted at the Mid South Area Poultry Research Unit and involved collaborators from Mississippi State University's College of Veterinary Medicine as well as from the Mid South Area Office of the Director. We determined that the ts-11 MG vaccine does not detrimentally affect any of the parameters measured when the hens are vaccinated at ten weeks of age. The outcome of this research is that now egg producers can make an informed decision regarding the use of this vaccine in their flocks. Most commercial layer chickens are infected with MG and most of these chickens remain "on the farm" for approximately 100 weeks of age; this becomes important when attempting to eradicate MG from multi-age layer operations, particularly in view of the fact that "the influence of age on resistance to disease has not been adequately examined." Chickens were maintained in biological isolation units at the Mid South Area Poultry Research Unit and chickens were infected at either 10 or 66 weeks of age whereupon recovery of the organism was attempted involving collaboration from Mississippi State University's College of Veterinary Medicine. Organism recovery data indicated that older infected hens are more efficient at suppressing the replication of the organism than are hens infected at a younger age. The ramification of this research impacts epidemiological investigations in that it suggests that older infected hens do not shed (implying that transmission to other hens is decreased) the organism as readily as younger infected hens. Most commercial layers are infected with MG and remain "on the farm" through 100 weeks of age during which time they are molted at about 65 weeks of age. Choanal cleft swabs were taken before and after molting during which time the birds were maintained in biological isolation units at the Mid South Area's Poultry Research Unit and involved collaboration from Mississippi State University's College of Veterinary Medicine. Molting was shown to result in a decreased ability to isolate MG from known infected chickens. This result has epidemiological ramifications in that it suggests that confirmatory MG isolation tests may be impaired when conducted on hens either in molt or immediately after molt.

5. Describe the major accomplishments over the life of the project including their predicted or actual impact. Major accomplishments over the life of the project include: a) the finding that the chicken remains infected over its life and that neither isolation nor disinfection of its environment will rid the chicken of the organism, impact - unless you can depopulate an infected farm, you cannot get rid of the organism from the flock, b) that the cellular profile of the chicken's blood reflects an acute infection with mycoplasma; however, the cellular blood profile of the chronically infected chicken is similar to control hens, despite the fact that the organism can still be isolated from the chronically infected hen, impact - the chicken's immune system is apparently "tricked" by the organism into believing there is no need to continue mounting an immune response, c) that the addition of the commonly used therapeutic agent ammonium chloride in layer chickens hinders the bacteriological recovery of *Mycoplasma gallisepticum* from chickens, impact - a diagnostician needs to know that a flock is being treated with ammonium chloride when he is attempting to isolate the organism and therefore take a greater number of swabs in order to assure the organism's isolation when the flock is actually infected, d) that vaccination of chickens at 10 weeks of age with the F strain of *Mycoplasma*

gallisepticum does not reduce egg production over a 44-week laying cycle, impact - since 1979, flock managers have used the F strain of *Mycoplasma gallisepticum* with the understanding that the vaccine reduces egg production by approximately 7 eggs/hen over a 45-week laying cycle. 6. What do you expect to accomplish, year by year, over the next 3 years? In 2000, we expect to demonstrate the effects of an available live MG vaccine (6/85) on egg production, egg size distribution, and egg and eggshell quality parameters of layer chickens. Further, we expect to sequence the genetic code and location of a putative gene associated with the ability of the MG organism to adhere to a host cell (cytadhesin gene) thereby inciting infection of the host. In 2001, we expect to investigate the effect of one of the most prevalent *Mycoplasma* species (*Mycoplasma gallinarum*) found in commercial layer chickens on egg production, egg size distribution, and egg and eggshell quality parameters. Also, we expect to show the impact of MG infection on the lipoprotein content of eggs and further, to evaluate the virulence of the cytadhesin gene sequenced in 2000. In 2002, we expect to demonstrate the impact of *Mycoplasma gallinaceum*, the second most prevalent *Mycoplasma* species found in commercial layer chickens, on egg production, egg size distribution, and egg and eggshell quality parameters. We also expect, contingent upon a determination of non-virulence in 2001, to insert the cytadhesin gene sequenced in 2000 into *Mycoplasma gallinarum* to result in the initiation of the development of a novel vaccine against MG. This novel vaccine will be capable of preventing colonization by wild or field strains of MG and will also result in enhanced interstate movement and export of commercial poultry by not resulting in positive seroconversion for both MG and MS tests. Finally, this vaccine should be more acceptable to the broiler and turkey industries as it will be protective against MG and MS yet cause no pathology. 7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product? Information pertaining to the effect of ts-11 MG vaccine on egg production, egg size distribution, Haugh unit measurement, egg shell breaking strength, blood meat spot incidence, pimpling incidence, and average egg weight has been made available to egg producers, veterinarians, and diagnosticians. Similarly, information regarding both molting and age of the chicken at the time of MG vaccination has been made available as it pertains to these factors potential for hindrance to isolation of the MG organism. The foregoing information is relevant immediately as approximately 80% of the commercial layer chickens are either infected or vaccinated with MG. This technology has been delivered to commercial layer managers via telephone call, reviewed journal articles, and conference talks. The value will continue as long as this vaccine is used in commercial layers. The only constraints to adoption of the technology rest with the individual states and whether they permit use of the vaccine within their borders. 8. List your most important non-peer reviewed publications and presentations to non-scientific organizations, and articles written about your work (NOTE: this does not replace your peer reviewed publications which are listed below). Becker, Hank. "Timing of vaccination could increase egg output." Poultry Times, March 22, 1999, p. 14. Becker, Hank. "Vaccinating hens at the right time saves eggs." Agricultural Research, March 1999, p. 17. Becker, Hank. "Vacc boost for egg production." ANIMAL PHARM World Animal Health and Nutrition News, July 2, 1999, p. 19.

PUBLICATIONS: 1999/01 TO 1999/09

1. BRANTON, S.L., LOTT, B.D., MAY, J.D., MASLIN, W.R., PHARR, G.T., BROWN, J.E. and

BOYKIN, D.L. 1999. The effects of F strain II. Egg size distribution. Avian Diseases 43:326-330.

2. BRANTON, S.L., MAY, J.D., LOTT, B.D. and PHARR, G.T. 1999. Effects of age at inoculation and induced molt on Mycoplasma gallisepticum from layer chickens. Avian Diseases 43:516-520.

3. BRANTON, S.L., LOTT, B.D., MAY, J.D. and MASLIN, W.R. 1999. The effects of ts-11 strain of Mycoplasma gallisepticum in commercial layer hens. Poultry Science (Suppl. 1):17.

4. BRANTON, S.L., SIMMONS, J.D., PHARR, G.T. and BROWN, J.E. 1999. Mycoplasma isolates in layer chickens. Poultry Science (Suppl. 1):107.

ACCESSION NO: 0177392 SUBFILE: CRIS

PROJ NO: MOR-9702552 AGENCY: CSREES MO.R

PROJ TYPE: NRI COMPETITIVE GRANT PROJ STATUS: TERMINATED

CONTRACT/GRANT/AGREEMENT NO: 97-35201-4936

START: 01 OCT 1997 TERM: 30 SEP 2000 FY: 2000 GRANT YR: 1997

INVESTIGATOR: CURTIS III, R.; WILMES-RIESENBERG, M.

PERFORMING INSTITUTION:

BIOLOGY

WASHINGTON UNIV

#1 NORTH BROOKINGS DRIVE, CAMPUS BOX 1137

ST LOUIS, MISSOURI 63130

ADHESINS FOR COLONIZATION OF CHICKENS & THEIR USE IN PREVENTION OF SALMONELLOSIS

OBJECTIVES: An understanding of the mechanism of Salmonella adherence to chicken cells could be particularly valuable when developing strategies to eliminate or reduce Salmonella colonization of poultry, and consequently, the shedding of Salmonella in feces, its transmission to eggs, and the cross-contamination of chicken carcasses which occurs during processing. The specific aims of this proposal are: to identify the gene(s) encoding the iron-induced adhesin, to evaluate the role of the iron-induced adhesin in the adherence of the Salmonella to avian cells in culture, the colonization of the chicken intestine, and the attachment of Salmonella to the surface of chicken carcasses and to determine if the iron-induced adhesin is made by other serotypes of S. enterica which colonize chickens.

APPROACH: The goals of this proposal are to identify the iron-induced adhesin and to evaluate its role in the adherence of the Salmonella to avian cells in culture, the colonization of chicken intestine, and in the attachment of Salmonella to the surface of chicken carcasses. This information may ultimately be used to design an avirulent S. typhimurium vaccine strain which will express the gene(s) encoding the lia constitutively, and to evaluate its potential to induce an immune response that would lessen the ability of S. typhimurium and other serotypes to colonize the intestinal tract of

chickens. The experiments proposed involve using a variety of genetic and molecular biology techniques. Mutants will be evaluated using tissue culture and animal models.

PROGRESS: 1999/10 TO 2000/09

Our long-term objective is to reduce or eliminate *Salmonella* colonization of poultry resulting in a reduction in the shedding of *Salmonella* in feces, transmission to eggs and cross contamination which occurs during processing. Toward this end, we initially constructed a *S. typhimurium* strain possessing knockout mutations in the genes encoding type 1 fimbriae (Fim), long polar fimbriae (Lpf), plasmid encoded fimbriae (Pef) and thin aggregative fimbriae (Agf). A derivative of this strain was also generated but lacking the ability to synthesize flagella, which can also serve as an adhesin. These strains were constructed to facilitate better identification of mutants defective in the expression of an iron-induced adhesin using *TnphoA* mutagenesis. Such a mutation, *iia-8::TnphoA* was identified in a *S. typhimurium* strain with a *phoP* allele to block synthesis of acid phosphatase which would then enable screening for strains that could or could not express alkaline phosphatase encoded by the *phoA* gene in the presence rather than in the absence of high iron concentrations. This *Iia*-defective mutant adhered to tissue culture cells with only 5 to 10 percent of the efficiency of wild-type cells under high iron conditions and with equal but low efficiency under low iron conditions. Using genomic subtractive hybridization and selective capture of transcribed sequences (SCOTS), we have identified another unique fimbrial operon, termed *stf*, in the *S. typhimurium* genome flanking the ferrochrome uptake operon. This *stf* fimbrial operon is similar to sequences encoding a mannose-resistant fimbrial type in *Proteus mirabilis*. Although the *stf* fimbrial operon is absent from the human pathogen *S. typhi*, it is present in the genomes of broad host range serovars that are specifically adapted to avian hosts. A *lacZ* reporter fusion was constructed, and studies demonstrated that the *stf* fimbrial operon was not regulated by iron concentration or by other environmental stimuli or stresses that affect expression of other fimbrial operons. A mutant with constitutive expression of *Stf* fimbriae has been constructed as well as a knockout mutant unable to synthesize *Stf* fimbriae. These mutants, as well as those with combination of these mutations and those affecting synthesis of other adhesins, including *Iia* fimbriae, will be evaluated for ability to colonize day-of-hatch chicks and to cause disease. Future studies will explore the potential effectiveness of the immune responses against these fimbrial adhesins in blocking the ability of *Salmonella* of diverse serotypes to colonize the avian intestinal track and thus to reduce the likelihood that the *Salmonella* will be transmitted through the food chain to humans.

IMPACT: 1999/10 TO 2000/09

We have identified six fimbrial adhesins, two newly identified by our efforts, that permit *Salmonella typhimurium* strains to effectively colonize the intestinal tract of chickens and thus become invasive. Flagella can also facilitate adherence and contribute to colonization of the avian intestinal tract. Using mutant strains with various constellations of mutations, colonization of the intestinal tract and virulence can be reduced significantly, if not eliminated. The results obtained permit us to postulate that effective immune responses against the 7 adhesins would likely abolish the ability of *Salmonella* strains to colonize the intestinal tract and be invasive and thus reduce the likelihood for *Salmonella* transmission through the food chain to humans.

PUBLICATIONS: 1999/10 TO 2000/09

1. Morrow, B.J., J.E. Graham, and R. Curtiss III. 1999. Genomic subtractive hybridization and selective capture of transcribed sequences identify a novel *Salmonella typhimurium* fimbrial operon and putative transcriptional regulator that are absent from the *Salmonella typhi* genome. *Infect. Immun.* 67:5106-5116.

2. Abstracts of poster presentations have been submitted for the 2001 general meeting of the American Society for Microbiology. Full-length papers describing our results are in preparation.

ACCESSION NO: 0402941 SUBFILE: CRIS

PROJ NO: 6612-32000-017-05T AGENCY: ARS 6612

PROJ TYPE: USDA INHOUSE PROJ STATUS: NEW

START: 26 APR 1999 TERM: 31 MAR 2000 FY: 2000

INVESTIGATOR: HOLT P S

PERFORMING INSTITUTION: AGRICULTURAL RESEARCH SERVICE, ATHENS, GEORGIA 30613

COMPARISON OF THE IMPACT OF ALTERNATIVE METHODS TO INDUCE INFECTION IN WHITE LEGHORN HENS

OBJECTIVES: Examine the impact of different molting procedures on a *Salmonella enteritidis* infection in chickens

APPROACH: Hens will be molted via feed removal, skip feeding, or low nutrition diets and then infected with *s. enteritidis*. The course of the infection in these hens will be compared with normal-fed hens. Trust Agreement with US Poultry and Egg Association

PROGRESS: 1999/01 TO 1999/09

1. What major problem or issue is being resolved and how are you resolving it? Induced molting is a prevalent procedure used by the layer industry to achieve a second egg lay from aging flocks. It is estimated that 70% of the flocks nationwide are molted. There are a variety of methods to induce a molt but taking the birds off feed until they drop 25-30% body weight is the preferred method. Early studies on molting showed that the effects of molting on a flock were primarily positive but we showed that the procedure depressed the immune system of the birds and dramatically exacerbated a *Salmonella enteritidis* (SE) infection. This increased the chance for the production of eggs contaminated with SE and therefore presented a food safety problem. Procedures need to be developed which will allow the producers access to this important economic tool while, at the same time, not putting the consuming public at risk for an SE infection. One procedure which we examined was the use of alternative molt procedures in the place of chronic feed removal to reduce or eliminate the exacerbated SE infection. We submitted a grant which was funded by the U.S. Poultry and Egg Association to examine the efficacy of using these alternative molt procedures to decrease or eliminate the SE problem. 2. How serious is the problem? Why does it matter? A 70% prevalence of molting means the procedure affects between 144-168 million hens annually - a

tremendous number of birds. It is estimated that approximately one third of the egg industry's profits is derived from molted birds which means that this is a very valuable industry tool. Successful completion of these studies could mean that the egg industry could use this important procedure without putting the consuming public at risk. The impact would therefore be dramatic. 3. How does it relate to the National Program(s) and National Component(s) to which it has been assigned? National Program 103, Animal Health (25%) National Program 108, Food Safety (75%) Food safety is a major component of the National Program agenda and intervention strategies which help prevent the dissemination of a human disease organism within flocks and block the entry of the organism into the human food chain are important areas of investigation. 4. What were the most significant accomplishments this past year? We wanted to see if feeding the hens a nonnutritive filler such as soybean hulls, which would provide the hens with bulk materials to keep the intestinal tract filled but yet provide no nutrition and therefore put the hens into a egg-laying pause, would result in a less severe intestinal infection compared with hens totally without feed. We found that the use of soybean hulls had a minimal effect on the SE infection at day 3 post challenge, compared with the fasted birds but there was a significant, 1000-fold SE decrease in the soybean hull group at day 10 post challenge, indicating that use of a nonnutritive diet can affect the SE situation during a molt. In a second group of experiments, we examined whether a shortened feed removal period, 6 days, followed by 3 alternating periods of 3 days on feed/1 day off, would result in lower intestinal SE levels compared with total feed withdrawal. As was seen in the soybean hull experiment, no significant effects were observed at day 3 post challenge but by day 10, there was a significantly lower number of SE in the intestinal tract of the birds receiving the skip feed procedure compared with the birds off feed for the entire time. These studies show that there are molting strategies which will allow producers to recycle their birds and not increase the risk of contaminated egg production. 5. Describe the major accomplishments over the life of the project including their predicted or actual impact. This CRADA has been going 0.5 years and question 4 is the data to date. 6. What do you expect to accomplish, year by year, over the next 3 years? This grant terminates on March 31, 2000. 7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product? None 8. List your most important non-peer reviewed publications and presentations to non-scientific organizations, and articles written about your work (NOTE: this does not replace your peer reviewed publications which are listed below).

PUBLICATIONS: 1999/01 TO 1999/09

No publications reported this period.

ACCESSION NO: 0149083 SUBFILE: CRIS

PROJ NO: 6202-42000-008-00D AGENCY: ARS 6202

PROJ TYPE: USDA INHOUSE PROJ STATUS: NEW

START: 01 MAY 1995 TERM: 30 APR 2000 FY: 2000

INVESTIGATOR: KOGUT M H; VACANT; VACANT

PERFORMING INSTITUTION: AGRICULTURAL RESEARCH SERVICE COLLEGE STATION,
TEXAS 77845

CYTOKINE-MEDIATED MODULATION OF THE INNATE IMMUNE RESPONSE TO PREVENT SALMONELLOSIS IN POULTRY

OBJECTIVES: 1) Produce cytokines or immune lymphokines in poultry by stimulation of spleen cells to proliferate in vitro; 2) identify functional activity of cytokines; 3) elucidate the mechanism of action of cytokines in poultry to aid in identification; 4) encapsule and/or bind cytokines to cell or other support matrix for delivery to neonatal chicks; and 5) purify cytokine(s) and cloning of gene for possible mass production.

APPROACH: Research will be focused on the identification and purification of cytokines which potentiate the innate immune responses of poultry that effectively prevent organ invasion of *Salmonella enteritidis*. Experiments will be conducted to separate and determine any effector cytokines present in our T cell supernatants and any host-derived cytokines induced endogenously in response to the injected material. Studies will be conducted to identify the specific components of a protective response and to elucidate the mechanisms of protection induced by a prophylactic administration of cytokines in neonatal chicks. Emphasis will be placed on the development of a cost-effective delivery system that can be incorporated into the poultry industry.

PROGRESS: 1999/01 TO 1999/09

1. What major problem or issue is being resolved and how are you resolving it? Despite the endeavors of researchers and public health agencies, the incidence of human salmonellosis has continued to increase over the past 20 years. Salmonellosis is now one of the most common food-borne causes of gastroenteritis. The number of reported cases of human salmonellosis exceeds 40,000 per year. The CDC estimates the true annual incidence of human salmonellosis in the US may be as high as 2 to 4 million cases/year. Animal food products are the principal source of human infections. Traditional management of infectious diseases in poultry has for the large part depended on the use of either broad-spectrum antibiotics and/or vaccines. Inappropriate use of antibiotics and concerns of antibiotic residues in meat causing microbial resistance in humans disease, has caused a public outcry demanding the removal of many antibiotics from animal feed and ultimately limiting future introduction of antibiotics for animal use. Vaccinations have limitations, at least 7-10 days are required for the stimulation of the acquired immune response for protection, and thus early protection for chicks from diseases is attempted through maternal antibodies. We propose an alternative immunological method for the control of infectious diseases, cytokine immunomodulation. Using avian cytokines as natural enhancers of the functional activity of the avian immune system results in direct protection against infectious diseases and provides an adjuvant-like promotion to any vaccine administered. Additionally, cytokines would be given during the first few days of life when the animals' immune system is functionally immature. Cytokines induce a very rapid protective response (within hours) which would last through this susceptible period of life. 2. How serious is the problem? Why does it matter? More than 8 billion broiler chickens are produced and commercially processed in the US each year. Research has indicated that

35% or more of all processed poultry meat products purchased by consumers may be contaminated by salmonellae. Because those *Salmonella* serotypes most often associated with human illness do not cause serious disease or grossly identifiable lesions in poultry, it has not been possible to eliminate contaminated poultry carcasses by inspection procedures during processing. Induced molting of laying hens is a common practice used by the US layer industry for the continual productivity of aging hens. However, induced molting has been linked to the decreased resistance and increased severity of *Salmonella enteritidis* (SE) in these hens. In fact, table eggs have been shown to be major sources of SE infections in humans with the risk of eggs becoming positive for SE contamination increasing threefold in flocks molted within the previous 10 weeks. Since 60% of the hens undergo a forced molt, approximately 200 million hens have an increased risk to SE infection. Salmonellosis in swine has been estimated to cost swine producers over \$100 million dollars/year in losses. 3. How does it relate to the National Program(s) and National Component(s) to which it has been assigned? Food safety belongs to a cross cutting program area. A major research direction in the Food Safety program (NP-108) is to decrease pathogenic bacteria. Targeted microbes include *Salmonella* spp. There is a need to develop integrated strategies for the prevention of *Salmonella* colonization and organ invasion in poultry and swine. One such strategy is the modulation of the host immune system. Immunological research on the control of intestinal and tissue colonization of poultry by invasive *Salmonella enteritidis* (SE) has largely focused on the development of live, attenuated vaccines. Regardless of the efficacy of a vaccine, at least 7-10 days are required for the stimulation of the acquired immune response for protection. Unfortunately for the poultry industry, neonatal poultry are most susceptible to *Salmonella* infections during the first 4 days post-hatch, after which they become increasingly more resistant to infection. During this first 4 days post-hatch we hypothesized immunopotentialization of the innate defense mechanism(s) would prevent *Salmonella* organ infectivity. 4. What were the most significant accomplishments this past year? This year tests were undertaken to determine the effects of induced molt on basal functional activities of heterophils from aging hens. The results indicated that feed withdrawal to induce molt alters the number and function of peripheral blood heterophils. This decreased efficiency of heterophil functional activity appears to play a role in the increased susceptibility of molting hens to *Salmonella enteritidis* infections. Preliminary investigations conducted during the last year demonstrated that the oral administration of *Salmonella enteritidis*-immune lymphokines (SILK) to hens 24 h before feed withdrawal for molting will prevent SE infections in the hens. These results suggest that SILK could become a commercial product for hens during induced molt that can convey protection against *Salmonella enteritidis* infections. During the last year, we conducted experiments that clearly showed that SILK delivered to day-old turkey poults orally, intranasally, and subcutaneously is effective in protecting the birds from SE infections. This protection is mediated by the activation of peripheral blood heterophils. These results are significant because we have now demonstrated in both chickens and turkeys multiple cost-effective industry friendly delivery systems for SILK. We have also conducted experiments to evaluate the effect of SILK on the incidence of horizontal transmission of *S. arizonae* in turkey poults and *S. gallinarum* in broiler chickens. Our results demonstrated that the immunoprophylactic administration of SILK to young turkey poults and broiler chicks significantly reduces the horizontal transmission of *Salmonella* in poultry. These results further suggest the possibility of using a non-vaccine immunologically-based preventive strategy against *Salmonella* in poultry. We also evaluated the effects of SILK on the phagocytic and bactericidal activities of

heterophils from chicks during the first 1-7 days of life. We demonstrated that following the administration of SILK, the functional activities of heterophils from 1-7 day-old birds is comparable to that of an immunologically mature (2-3 weeks of age) bird. Mechanistically, these functionally mature heterophils are responsible for the protective inflammatory response, which protects the birds from salmonellae infections. These data demonstrate that SILK augments the innate host defenses in chicks during the greatest period of susceptibility to *Salmonella* infections. We have also demonstrated that recombinant chicken interferon-gamma (rChIFN-gamma) is capable of enhancing the functional activities of heterophils from day-of-hatch chicks. These results demonstrate that the heterophils from neonatal chicks possess the receptor for IFN-gamma; thus, this cytokine could possibly be used either as an immunopotentiator for day-old chicks or as an adjuvant for vaccines. We conducted studies to identify the specific protein in SILK responsible for the protective effect in chickens. SILK was fractionated by ammonium sulfate precipitation and the protective activity was recovered in the 40- 60% ammonium sulfate saturation fraction. Monoclonal antibodies against SILK were then linked to a solid matrix to form an immunoaffinity column over which the 40-60% fraction was run. The recovered activity was then subjected to size exclusion, ion exchange, and hydrophobic interaction chromatography. Isolation of the SILK protein will enable us to clone the gene for this protein that will be a useful tool for the development of economical and effective immunologically-based treatments for the reduction of *Salmonella* in poultry products.

5. Describe the major accomplishments over the life of the project including their predicted or actual impact. Our laboratory has been evaluating the practicality of potentiating the endogenous innate host defenses of poultry using immune and inflammatory cytokines. Cytokines, chemical messengers secreted by various immune and non-immune cells, are some of the most effective mediators of natural host defenses. Specifically, we have found that the prophylactic administration of cytokines derived from T cells (SILK) isolated from *Salmonella* enteritidis-immune chickens have a favorable effect in controlling or eliminating salmonellosis in neonatal poultry and hens undergoing induced molting. This resistance is associated with a dramatic peripheral blood leukocytosis after the injection of the SILK followed by a marked infiltration of bactericidal inflammatory heterophils in the lamina propria of the ceca. Heterophils are highly phagocytic, polymorphonucleated white blood cells which are important mediators of innate resistance in poultry; especially in young birds that have not yet developed an acquired immune response. Under normal conditions, invasion of the intestinal mucosa by *Salmonella* spp. initiates the recruitment of heterophils to the lamina propria which control bacterial numbers in the bird until the development of acquired immunity. Administration of SILK into neonatal chicks induces a significant increase in the production and release of heterophils into the peripheral blood and also augments the effector functions of these phagocytes. Thus, salmonellae infections are not only controlled but eliminated from chicks following the administration of SILK. Further studies indicate that the delivery of SILK either in ovo at 18- days of embryogenesis or orally and as an aerosol at hatch can be used by the poultry industry to confer protection to chickens against a localized enteric SE organ invasion by potentiating the systemic heterophilic innate response.

6. What do you expect to accomplish, year by year, over the next 3 years? In FY-00, we hope to identify and purify the effector cytokine(s) in SE- ILK and clone the gene for mass production. We also hope to identify and clone genes for many avian cytokines for use in the immunopotential of host immune responses in neonatal poultry. Genes for interferon-gamma and the putative homologue of human IL- 8, 9E3/CEF4 have been cloned in our laboratory and they will be evaluated for their

protective abilities in our Salmonella models. This CRIS will terminate in April FY-00. 7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product? SILK has been sent to scientists all over the world for use in research in immunology enhancement of the avian and porcine immune systems, as well as for evaluation in the prevention and control of various viral, bacterial, and protozoal diseases of food animals. The main constraint for the transfer of this technology is the purification and identification of the effector molecules in the SILK. Once we can fully identify the components of our SILK soup the pharmaceutical industry will license this material. In addition, we have developed a CRADA with Cobb-Vantress Poultry Breeders to evaluate the effect of SILK in commercial birds. 8. List your most important non-peer reviewed publications and presentations to non-scientific organizations, and articles written about your work(NOTE: this does not replace your peer reviewed publications which are listed below). Heterophils to the Rescue! Agricultural Research p. 9. July, 1997.

PUBLICATIONS: 1999/01 TO 1999/09

1. KOGUT M.H., HOLTZAPPLE C., LOWRY V.K., GENOVESE, K. and STANKER, L.H. 1998. Comparison of the functional and turkey heterophils in response to stimulation by inflammatory agonists. Am. J. Vet. Res. 59:1404-1408.
2. GENOVESE, K.J., LOWRY, V.K., STANKER, L.H. and KOGUT, M.H. 1998. Administration of Salmonella enteritidis-immune lymphokine blood heterophilia, and heterophil activation. Avian Pathol. 27:597-604.
3. LOWRY, V.K., NISBET, D.J., STANKER, L.H. and KOGUT, M.H. 1999. Efficacy of Salmonella enteritidis-immune turkeys and S. gallinarum in chickens. Int. J. Food Microbiol. 48:139-148.
4. GENOVESE, L.L., LOWRY, V.K., GENOVESE, K.J. and KOGUT, M.H. 1999. Enhancement of phagocytosis and bacterial administration of Salmonella enteritidis-immune lymphokines. Vet. Microbiol. 65:133-143.

ACCESSION NO: 0153343 SUBFILE: CRIS

PROJ NO: IND073045V AGENCY: CSREES IND

PROJ TYPE: ANIMAL HEALTH PROJ STATUS: TERMINATED

START: 07 MAY 1996 TERM: 30 SEP 2000 FY: 2000

INVESTIGATOR: SAEED, A. M.; ASEM, E. K.; CSONCO, L.

PERFORMING INSTITUTION:

VETERINARY PATHOBIOLOGY

PURDUE UNIVERSITY

WEST LAFAYETTE, INDIANA 47907

VIRULENCE FACTORS OF SALMONELLA ENTERITIDIS AND INFECTIVITY FOR THE

AVIAN REPRODUCTIVE SYSTEM

OBJECTIVES: To characterize the virulence factors in *Salmonella enteritidis* isolates from poultry, eggs and human cases of food poisoning to study the relatedness among *Salmonella* isolates from different sources and to establish pathotypes for the organism that may be associated with disease outbreaks in commercial poultry flocks, which result in the production of *Salmonella* infected eggs.

APPROACH: To use the characteristics of *Salmonella* pathotypes in experimental infection of egg-laying hens and study the course of the disease microbiologically, pathologically and serologically to identify useful markers for the diagnosis of the disease and characterize *Salmonella* infectivity to the avian reproductive system.

PROGRESS: 1996/05 TO 2000/09

Salmonella Enteritidis is among the most virulent *Salmonella* Serotypes in humans and animals. In the US. More than 25 percent of all cases of salmonellosis in humans are associated with eating raw or undercooked eggs. In previous reports we demonstrated that egg contamination may take place transovarially. Our recent investigation targeted the virulence factors of *Salmonella Enteritidis* that enable the organism to contaminate the preovulatory follicles of the laying hen that leads to the contamination of laid eggs. We produced knockout mutants of three phage types of *Salmonella Enteritidis* such that their flagellar expression was suppressed. We studied the role of flagella in the in vitro attachment and invasion of the avian ovary cells maintained in primary tissue culture. We found that flagellar suppression was associated with the failure of the organism to attach or invade the avian ovary cells compared to the parent or wild flagellated strains. We also found that incubating the inoculated cells at 42C, which is closer to the normal temperature of the avian species, enhanced flagellar expression. These results may suggest the preference of hens by the *salmonella* organisms as a major reservoir.

PUBLICATIONS: 1996/05 TO 2000/09

Popiolarczyk. M., Asem E., Koons. C., Csanco. L., Kazocos. E., Thacker. L. Saeed. A.M.. The role of flagella in the virulence of *Salmonella Enteritidis*. pp 425-439. in Proceedings of the 103rd Annual Meeting of the United States Animal Health Association. San Diego, CA, October 7-14. 1999

Termination Year 1999

ACCESSION NO: 0401397 **SUBFILE:** CRIS

PROJ NO: 6612-32000-019-01T **AGENCY:** ARS 6612

PROJ TYPE: USDA INHOUSE **PROJ STATUS:** TERMINATED

START: 01 DEC 1997 **TERM:** 30 NOV 1999

INVESTIGATOR: HOLT P S; GAST, R. K.

PERFORMING INSTITUTION:
AGRICULTURAL RESEARCH SERVICE
ATHENS, GEORGIA 30613

IMPLEMENTATION OF INTERVENTION MEASURES TO REDUCE SALMONELLA ENTERITIDIS INFECTIONS IN CHICKENS

OBJECTIVES: Examine the utility of using different licensed products as intervention measures to reduce the severity of Salmonella enteritidis infections in birds exposed during periods of high susceptibility.

APPROACH: Subject hens to induced molting procedure and infect with Salmonella enteritidis. Use antibiotics in the presence or absence of probiotics to eliminate infection. Subject hens to induced molting procedure and infect select hens with Salmonella enteritidis. Treat part of the unchallenged hens with probiotics while the others remain untreated to examine the effects of the probiotics on horizontal transmission of the Salmonella enteritidis. Infect one day old chicks with Salmonella enteritidis in the presence or absence of probiotics to examine the effects of treatment on long term persistent infections and immunodepression. CRADA with Bayer Corporation.

PROGRESS: 1999/01 TO 1999/11

1. What major problem or issue is being resolved and how are you resolving it? Induced molting is a prevalent procedure used by the layer industry to achieve a second egg lay from aging flocks. It is estimated that 70% of the flocks nationwide are molted. There are a variety of methods to induce a molt but taking the birds off feed until they drop 25-30% body weight is the preferred method. Early studies on molting showed that the effects of molting on a flock were primarily positive but we showed that the procedure depressed the immune system of the birds and dramatically exacerbated a Salmonella enteritidis (SE) infection. This increased the chance for the production of eggs contaminated with SE and therefore presented a food safety problem. Procedures need to be developed which will allow the producers access to this important economic tool while, at the same time, not putting the consuming public at risk for an SE infection. One procedure which we examined was the use of antibiotics, in combination with reconstituting the intestinal bacterial flora with competitive exclusion cultures, to eliminate the SE problem. We established a CRADA with Bayer Corporation, marketers of the fluoroquinolone antibiotic enrofloxacin and a competitive exclusion culture, to examine the efficacy of treating with these products to decrease or eliminate the SE problem.

2. How serious is the problem? Why does it matter? A 70% prevalence of molting means the procedure affects between 144-168 million hens annually - a tremendous number of birds. It is estimated that approximately one third of the egg industry's profits is derived from molted birds which means that this is a very valuable industry tool. Successful completion of these studies could mean that the egg industry could use this important procedure without putting the consuming public at risk. The impact would therefore be dramatic.

3. How does it relate to the National Program(s) and National Component(s) to which it has been assigned? National Program 103, Animal Health (25%) National Program 108, Food Safety (75%) Food safety is a major component of the National Program agenda and intervention strategies which help prevent the dissemination of a human disease

organism within flocks and block the entry of the organism into the human food chain are important areas of investigation. 4. What were the most significant accomplishments this past year? We wanted to see if treatment of molted infected birds with antibiotics and competitive exclusion cultures would decrease the SE infection after the molt. Birds were molted, infected with SE 4 days into the feed removal, and then put back on feed after 14 days. They were put on a regimen of antibiotics for 10 days followed by two days of competitive exclusion administration. We showed that antibiotic treatment after the birds went back on feed reduced the percentage of infected birds from 33% and 25% to 4% and 0% in experiments one and two, respectively. The addition of the competitive exclusion cultures were critical in the protection. These studies showed that there are intervention strategies which will allow producers to molt their birds and not increase the risk of contaminated egg production. 5. Describe the major accomplishments over the life of the project including their predicted or actual impact. This CRADA has been going 1.5 years and question 4 is the data to date. 6. What do you expect to accomplish, year by year, over the next 3 years? This CRADA will be terminated at the end of the calendar year. 7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product? N/A 8. List your most important non-peer reviewed publications and presentations to non-scientific organizations, and articles written about your work(NOTE: this does not replace your peer reviewed publications which are listed below). HOLT, P.S. Possible intervention strategies for Salmonella enteritidis problems in layer hens. Poultry Diagnostic and Research Center, University of Georgia, January 1999.

PUBLICATIONS: 1999/01 TO 1999/11

SEO, K.-H., HOLT, P.S., ... 1999. Combined effect of antibiotic and competitive exclusion treatment on Salmonella enteritidis fecal shedding in molted laying hens. Proceedings of the 86th IAMFES meeting, pp 55-56.

ACCESSION NO: 0401397 SUBFILE: CRIS

PROJ NO: 6612-32000-019-01T AGENCY: ARS 6612

PROJ TYPE: USDA INHOUSE PROJ STATUS: TERMINATED

START: 01 DEC 1997 TERM: 30 NOV 1999

INVESTIGATOR: HOLT P S; GAST, R. K.

PERFORMING INSTITUTION: AGRICULTURAL RESEARCH SERVICE ATHENS, GEORGIA 30613

IMPLEMENTATION OF INTERVENTION MEASURES TO REDUCE SALMONELLA ENTERITIDIS INFECTIONS IN CHICKENS

OBJECTIVES: Examine the utility of using different licensed products as intervention measures to reduce the severity of Salmonella enteritidis infections in birds exposed during periods of high

susceptibility.

APPROACH: Subject hens to induced molting procedure and infect with *Salmonella enteritidis*. Use antibiotics in the presence or absence of probiotics to eliminate infection. Subject hens to induced molting procedure and infect select hens with *Salmonella enteritidis*. Treat part of the unchallenged hens with probiotics while the others remain untreated to examine the effects of the probiotics on horizontal transmission of the *Salmonella enteritidis*. Infect one day old chicks with *Salmonella enteritidis* in the presence or absence of probiotics to examine the effects of treatment on long term persistent infections and immunodepression. CRADA with Bayer Corporation.

PROGRESS: 1999/01 TO 1999/11

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PUBLICATIONS: 1999/01 TO 1999/11

SEO, K.-H., HOLT, P.S., ... 1999. Combined effect of antibiotic and competitive exclusion treatment on Salmonella enteritidis fecal shedding in molted laying hens. Proceedings of the 86th IAMFES meeting, pp 55-56.

ACCESSION NO: 0167506 SUBFILE: CRIS
PROJ NO: IOWV-400-25-27 AGENCY: CSVM IOWV
PROJ TYPE: STATE PROJ STATUS: TERMINATED
START: 01 JUL 1994 TERM: 30 JUN 1999 FY: 1995

INVESTIGATOR: REYNOLDS, D. L.

PERFORMING INSTITUTION:
VETERINARY MEDICINE
IOWA STATE UNIVERSITY
S. & 16TH ELWOOD
AMES, IOWA 50011

STUDIES ON THE EFFICACY OF A SWINE SALMONELLA VACCINE FOR PREVENTION OF SALMONELLA COLONIZATION IN

OBJECTIVES: The objective of this study is to evaluate the feasibility of using a swine salmonella vaccine for use in poultry.

APPROACH: The experimental design and approach for evaluating safety and efficacy of the swine vaccine for use in poultry is very direct and straight-forward and is as follows: All birds used will be specific pathogen free (SPF) leghorn type. These birds will be hatched and reared at our facility designed for maintaining SPF status. The SC-54 modified live vaccine will be supplied by a commercial laboratory and used at 10/8 CFUs/chick administered intranasally. A nalidixic acid

resistant strain of *Salmonella enteritidis* will be used at a challenge dosage of 10/8 CFUs per bird. Four groups of birds will be used as follows: 1) unvaccinated, unchallenged; 2) unvaccinated, challenged; 3) vaccinated, unchallenged; 4) vaccinated, challenged. Day-old birds will be intranasally vaccinated with SC-54 and will be challenged at 2 weeks of age. Birds will be monitored daily for the presence of clinical signs of disease. At 8 to 10 days following inoculation birds will be euthanized, data and samples will be collected for evaluation. Parameters of evaluation include 1) number of salmonella (CFUs) per gram of cecal content, 2) clinical signs and/or lesions of disease, 3) body weights, 4) serologic antibody to pullorum antigen (plate test), 5) organ cultures of liver and spleen will be done.

PROGRESS: 1995/01 TO 1995/12

A commercially licensed live *Salmonella* swine vaccine was evaluated for efficacy in protecting chickens from *Salmonella enteritidis* infections. It was found that there was no efficacy in protecting chickens from SE infections.

PUBLICATIONS: 1995/01 TO 1995/12

No publications reported this period.

PROJ CONTACT:

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Email: dlr@iastate.edu

ACCESSION NO: 0149221 SUBFILE: CRIS

PROJ NO: 3602-32000-002-00D AGENCY: ARS 3602

PROJ TYPE: USDA INHOUSE PROJ STATUS: NEW MULTISTATE PROJ NO: W-173

START: 10 NOV 1994 TERM: 09 NOV 1999 FY: 1999

INVESTIGATOR: SHEA MOORE M M; VACANT; VACANT; PRUIETT S D

PERFORMING INSTITUTION: AGRICULTURAL RESEARCH SERVICE WEST LAFAYETTE, INDIANA 47907

ETHOLOGY OF FOOD PRODUCING ANIMALS

OBJECTIVES: Identify internal states of animal cognition and learning. Establish objective indicators of well-being (behavioral, immunological, neuroendocrinological and molecular). Determine how well-being in food producing animals relates to behavior, health and production efficiencies.

APPROACH: Develop physiological measures as indicators of stress and well-being including

immune and neuroendocrine responses as well as alterations in gene products in food producing animals. Measure behavior and learning in livestock to identify animal interactions with the production environment and identify conditions that both cause and alleviate stress. Combine physiological and behavioral measures to define cause and effect relationships between well-being and production efficiency in food animals.

PROGRESS: 1999/01 TO 1999/09

1. What major problem or issue is being resolved and how are you resolving it? Determination of objective indicators of animal cognition and well-being in food producing animals. We have developed a team consisting of expertise in ethology, immunology and neuroscience combined with highly skilled technicians to ensure a multidisciplinary approach to answering complex whole-animal questions. 2. How serious is the problem? Why does it matter? Animal welfare is an international issue and consumers of food products in this country are beginning to demand to know how the animals are raised and cared for in production systems. If information on the well-being of food-producing animals is not provided by scientifically assessing the animal's welfare, then emotional, subjective opinions will be used to provide this information to the consumer. This will in turn, be harmful to the American Producer with no scientific evidence to support or contradict the opinions. Ultimately, the market for U.S. livestock products will be affected both locally and internationally. 3. How does it relate to the National Program(s) and National Component(s) to which it has been assigned? This project is in direct concurrence with National Program 105. All of the research conducted in this project directly addresses the "Animal Stress and Well-Being, 105" National Program. 4. What were the most significant accomplishments this past year? As this project progresses, advances in determining indicators of well-being are being made in the species studied. Behavioral and immunological data continue to show advantages to all tail-banding first calf heifers over young calves. Calves show higher levels of agitative behaviors and elevations in acute phase proteins (liver proteins released in response to tissue trauma) if docked in close proximity to banding date. Additionally, a new study has shown improvements in immunological & productivity measures when first-calf heifers are exposed to a pre-milking experience prior to calving. The implications of this study suggest that gradual habituation of the animal to a management procedure, such as milking, improves the well-being of the animal. Further progress was also made with the different genetic lines of pigs selected for lean gain. The most significant accomplishment in this area of research was to combine the genetic lines with a transportation stressor. Results indicated that pigs selected for lean growth show significantly higher levels of aggressive activity when mixed during transportation. These data compliment the previous data describing greater handling problems in these pigs selected for lean growth. Salivary stress hormones, although significantly elevated due to transportation stress, were not higher in pigs selected for lean gain over other genotypes. Furthermore, genotype did not affect the meat quality scores after transportation. Finally, significant progress was made in the area of cognition work this year. It was shown that piglets are capable of perceiving and remembering olfactory and gustatory cues presented in their prenatal environment, affecting postnatal behavior. By adding volatile compounds to diets during gestation, it may be possible to increase feed consumption and reduce stress at weaning. 5. Describe the major accomplishments over the life of the project including their predicted or actual impact. The major accomplishment over the life of this project is the building of an interdisciplinary team to address

complex questions about animal welfare across three species, dairy, swine and poultry. To combine neuroscience, immunology, and ethology in comprehensive approaches to answering animal welfare questions is very difficult. We have made significant progress in this area. Furthermore, we have built teams with scientists at Purdue University to incorporate genetics, nutrition and production to strengthen our approach to welfare questions. This is an essential component to the success of this project.

6. What do you expect to accomplish, year by year, over the next 3 years? Year 1: Addition of 2 new scientists to expand our interdisciplinary team. One neuroscientist with expertise in gross morphology/structure/function, and one new post-doctoral scientist to focus in the area of neuroethology (relationship between the brain and behavior) in dairy, swine and poultry. These two people will establish a quantifiable link between management systems and animal welfare by incorporating the role of the brain into new and ongoing projects in our unit. Year 2: Both the first and second year will also determine both chronic and/or acute 'pain', associated with common industry practices (beak trimming, induced molting, tail docking) in conjunction with the expression/lack of expression of behavior in these animals. There is a politically sensitive concern between forced molting and food safety (*Salmonella enteritidis*) currently under discussion in the U.S. Year 2 and 3 will try to connect this information with animal welfare (neuroscience, stress physiology, immunology and behavior). Year 3: We should have a full-team of scientists hired into our unit at this point. This will include: 2 ethologist (one of whom will address food safety concerns in connection with behavior), 1 immunologist, 1 neuroscientist (1 neuroethologist, postdoc), 1 animal scientist, and possibly a gut microbiologist. This unit should be up to full-speed by year 3 with a significant scientific contribution to the area of animal welfare science.

7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product? Data from three research projects on tail docking in dairy cattle were summarized in a letter published in *Hoard's Dairyman* (May 25, 1999, Vol. 144 #10, p. 390). Currently being disseminated to the dairy industry, are results from a study using pre-milking in dairy heifers to decrease the stress of first milking in first-calf heifers. This information has been shared with and presented by Purdue Dairy Extension Specialists to producers in Indiana. One of our ARS scientists will present this information in an invited seminar at the University College Dublin, Animal Science and Production Department in September, 1999. A primer for the porcine IL-1 receptor antagonist was developed and will be listed as available for other scientists as earlier as October, 1999. This work will permit us to look at the microenvironment of the pig for early cell signals in response to stressors (environmental, physiological, social). The receptor antagonist modulates the early response of cytokines to stress.

8. List your most important non-peer reviewed publications and presentations to non-scientific organizations, and articles written about your work (NOTE: this does not replace your peer reviewed publications which are listed below).

PUBLICATIONS: 1999/01 TO 1999/09

1. BUSSE, C. and SHEA-MOORE, M. 1999. Behavioral and physiological responses to transportation stress on three genetic lines of pigs. *J. Anim. Sci.* 77 (Suppl. 1):147.
2. EICHER-PRUIETT, S.D. and MORROW-TESCH, J.L. 1999. Tail-docking alters behavior but not acute phase proteins of young dairy calves. *J. Dairy Sci.* 82:842.

3. EICHER-PRUIETT, S.D. and SCHUTZ, M.M. 1999. Prepartum milking of Holstein heifers: II Effect on acute phase proteins and immune activation. J. Dairy Sci. 82 (Suppl. 1):60.
4. EICHER-PRUIETT, S.D. 1999. Data on Docking. p. 390 IN: Hoard's Dairyman Vol.144 N o. 10. Eds.:Knox and Larson.
5. SCHUTZ, M.M. and EICHER, S.D. 1999. Prepartum milking of Holstein heifers: I Effects on production, parturition, edema, and SCC. J. Dairy Sci. 82 (Suppl. 1):60.
6. SCOTT, K.A. and SHEA-MOORE, M. 1999. Influence of sow gestation diet on piglet behavior. J. Anim. Sci. 77 (Suppl. 1):145.
7. SHEA-MOORE, M. 1999. Social behavior of Pekin ducks raised in a production environment. 33rd Intl. Congress of the Intl. Soc. for Appl. Ethology. P. 183.

ACCESSION NO: 0173189 SUBFILE: CRIS
PROJ NO: GEO00812 AGENCY: CSREES GEO
PROJ TYPE: HATCH PROJ STATUS: TERMINATED
START: 01 NOV 1996 TERM: 31 OCT 1999 FY: 1999

INVESTIGATOR: WEBSTER, A. B.

PERFORMING INSTITUTION: POULTRY SCIENCE UNIVERSITY OF GEORGIA ATHENS,
 GEORGIA 30602

WELFARE ASPECTS OF INDUCED MOLTING PROGRAMS

OBJECTIVES: To assess the welfare impact on hens of extended feed withdrawal typical of commercial induced molting programs for commercial layers.

APPROACH: To obtain quantitative measures of behavior, plasma corticosterone and heterophil:lymphocyte ratios during an induced molt and second cycle of egg production. To assess the capacity of hens to react to an additional stressor during a fast by recording behavior and plasma corticosterone of fasting hens in open field tests. To determine if hens experience increasing levels of hunger during a fast, and to determine if hens have sufficient cognitive capacity to suffer during a fast by recording the behavior of trained, fasting hens in a standardized test in which a food reward which might be expected is withheld.

PROGRESS: 1996/11 TO 1999/10

The first phase of this project has been wound up. Behavioral changes of hens during the molt fast reflected conservation of bodily reserves rather than debilitation. A small increase in aggression occurred on the first day of feed withdrawal. Increased attentiveness and stimulus generalization in foraging behavioral patterns was evident on the second day of feed withdrawal. Afterward, hens appeared to adjust expectations in regard to feeding opportunity although behavior associated with foraging and feeding did not disappear entirely. Hens which experienced feed withdrawal had significantly better survival during the second production cycle than did control hens. Preparations

are being made to develop the next phase, which will involve investigation of the variation of motivational strengths in relation to hunger. This research will shed light on changes in a hen's cognitive status during feed withdrawal and determine if the potential for a hen to suffer during feed deprivation reaches a steady state or increases continuously with time off feed.

PUBLICATIONS: 1996/11 TO 1999/10

Webster, A.B., 2000. Behavioral changes of laying hens during feed withdrawal. Poultry Science: (in press)

Termination Year 1998

ACCESSION NO: 0149691 SUBFILE: CRIS

PROJ NO: 6612-32000-017-03S AGENCY: ARS 6612

PROJ TYPE: USDA COOPERATIVE AGREEMENT PROJ STATUS: TERMINATED

CONTRACT/GRANT/AGREEMENT NO: 58-6612-6-012

START: 08 JAN 1996 TERM: 30 SEP 1998 GRANT YR: 1997

INVESTIGATOR: PETTER, J. G.; MATIN, A.

PERFORMING INSTITUTION:

MICROBIOLOGY & IMMUNOLOGY

STANFORD UNIV

PALO ALTO, CALIFORNIA 94305

PRODUCTION OF SALMONELLA ENTERITIDIS SUBUNIT VACCINES

OBJECTIVES: To produce stabilized populations of *S. enteritidis* that hyperexpress virulence factors using continuous culture technology.

APPROACH: Specific nutrients will be titrated into cell populations at defined dilution rates. Once stabilized, samples of cells will be assayed for the production of virulence factors, which include but are not limited to lipopolysaccharide, flagella, invasomes, and pili. Those conditions that are found to produce copious amounts of virulence factors will be used to obtain enough cells for the production of a pilot killed subunit vaccine.

PROGRESS: 1998/01 TO 1998/09

1. What major problem or issue is being resolved and how are you resolving it? Vaccines made from killed cells have been made by industry for years as aids to prevent colonization and organ invasion by *Salmonella enteritidis* and other salmonellae. However, these products lack the level of efficacy (greater than 90% protection) that is the usual hallmark of a highly successful vaccine. We believe that partial protection by vaccines can in some cases perpetuate problems with infection by this

organism rather than solve them. Our research indicates current products do not provide a high degree of protection against *S. enteritidis*, possibly because new information about subpopulation biology is not incorporated into current methods for preparing vaccines. The research of many investigators already indicates that *Salmonella* isolates vary in their ability to survive in the environment, to colonize the intestinal tract, to invade the mucosa, to gain access to internal organs via the lymphatic or circulatory systems, and to survive intracellularly. Indeed, mutations introduced into *Salmonella* produces defined strains that target one niche versus another, but do not complete a cycle of pathogenesis because an essential ability to undergo change has been deleted. At SEPRL, scientists have concentrated on understanding what characteristics enable *Salmonella enteritidis* to be so invasive that eggs become routinely contaminated with this pathogen. Contamination of eggs is the final outcome of infection in hens that affects the food safety, because eggs are the most important source of *S. enteritidis* for people. Research at SEPRL indicates that the ability of *S. enteritidis* to contaminate eggs can be tracked by following the structure of the predominant outer membrane molecule lipopolysaccharide (LPS), and indeed, some strains produce a structure much like that of *S. typhi*, the causative agent of typhoid fever. This phenomena is known as LPS O-chain phase variation. The importance of this phenomena to manufacturers of vaccines is that production of immunogenic cell-surface proteins change in coordination with changes in LPS O-chain structure. In addition, *S. enteritidis* appears to be able to produce *S. typhi*-like LPS while it grows to very high cell densities. Because these biological capabilities are so remarkable, scientists at SEPRL have developed special strains and methods to improve second generation bacterins intended to aid in the prevention of egg contamination specifically and organ invasion by any salmonellae in general. 2. How serious is the problem? Why does it matter? *Salmonella enteritidis* has emerged within the last fifteen years to become the leading cause of salmonellosis around the world, with overall incidence of human illness increased from 5 to 40 fold depending upon the country. The most frequently identified food source for this pathogen is the hen's egg, and wherever isolation of this organism from eggs has increased, so has human salmonellosis. While the United States does not yet have a problem of epidemic proportions, with risk of consuming a contaminated egg estimated at about 1 in 5,000 to 10,000 eggs consumed, the European problem is at least 10 times worse, with risk of eating a contaminated egg estimated at between 1 in 100 (Germany) to 1 in 700 eggs consumed (United Kingdom). Since incidence of infection with *S. enteritidis* in Central America, South America and Pacific Rim countries is also estimated to be much worse than within the USA, the potential for eggs produced in this country to become contaminated at epidemic levels is ever present. Infection of people by *S. enteritidis* is indeed a serious problem for USDA due to its association with poultry. 3. How does it relate to the National Program(s) and National Component(s) to which it has been assigned? This research allowed scientists to develop novel methods for increasing the efficacy of bacterins against *Salmonella enteritidis*. This project ended 9/30/98. 4. What were the most significant accomplishments this past year? A patent award was received on a special medium and associated intellectual property that describes enhanced recovery of proteins from *Salmonella enteritidis* that produces Typhi-like lipopolysaccharide. This patented medium in general supports high cell density growth and cellular differentiation of the salmonellae. 5. Describe the major accomplishments over the life of the project including their predicted or actual impact? . The actual impact of this research is that it broadens our knowledge about how *Salmonella enteritidis* became a world wide problem. The predicted impact is that the information can be used to understand how

sustained epidemics (greater than 10 years) due to bacterial pathogens come into existence. Specific accomplishments are as follows: 1) A strain of *Salmonella enteritidis* was developed that efficiently contaminates eggs and that greatly improved our ability to assess the efficacy of vaccines, both killed and modified live products. This new strain produces a plethora of cell-surface proteins and grows to cell densities two logs higher than the parent strain. Surprisingly, use of this strain in animals also indicated that parenteral adaptation is required to achieve efficient egg contamination. This finding confirmed previous results that indicated an orally invasive phenotype was required to be mixed with parenterally adapted phenotypes in order to achieve egg contamination following oral infection. 2) Collaboration with Dr. A.C. Matin of Stanford University helped expose yet another problem associated with production of bacterins. Dr. Matin grew a wildtype attenuated strain of *Salmonella enteritidis* in continuous culture, but found he could get good protein production only in diluted medium. Since economical production of bacterins requires growth of bacteria to high cell yields, this collaboration confirmed that SE-HCD, which can produce lots of cell-surface proteins at high-cell-densities in rich broth, was a crucial development. Dr. Matin has been asked for a final report on this collaborative research, which is still pending. 3) At least 3 manuscripts were published that described findings from these studies as they were pursued for their relevance to general objectives of CRIS 6612-32000-017. One of these papers describes the intellectual property associated with the patented medium. Two others describe the recovery from farms of invasive *Enteritidis* that grows to high cell density and the unique growth properties of a genetically modified strain of *Salmonella enteritidis* that grows to high-cell-density (SE-HCD). 4) Use of the patented growth medium revealed that serotyping can be used to do more than just name salmonellae according to the LPS O-chain and flagellar antigens they produce. It appears that the patented medium produces unexpected changes in serotype that can be used to assess invasive potential and important aspects of epidemiology. 5) The patented medium also detects metabolites present in hen houses that can cause cells to undergo differentiation into potentially more invasive forms. New lines of research with relevance to major CRIS objectives are originating from this use. 6. What do you expect to accomplish, year by year, over the next 3 years? This proj. has ended. However, we are now in a new stage of applying these findings. We will be growing SE-HCD in continuous culture to begin defining the exact conditions for maximizing both cell-surface protein and cell yields. These two factors are crucial to producing pilot vaccines with enhanced efficacy that can be produced en masse. 7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product? The patented medium is now available for non-exclusive licensing. The technology is available now. One major constraint to the adoption of the technology is a lack of understanding of the new information and how it addresses practical issues. Another major constraint is that this research has been dependent upon the efforts of one scientist who has no authority to scientific support staff to build upon this research. To educate USDA staff and other scientists about the impact this new information could have on issues of food safety, ARS News is planning an article on how bacterial cells communicate when they grow to high cell density, how high cell density growth changes gene regulation, and how novel research conducted at SEPRL provides the first clear evidence that these factors are important to improving food safety. 8. List your most important non-peer reviewed publications and presentations to non-scientific organizations, and articles written about your

work(NOTE: this does not replace your peer reviewed publications which are listed below) .
Presentations: Approved Patent: "A complex growth supplement for maintenance of bacterial cell viability and induction of bacterial cell differentiation." Uses of the medium include improving bacterins and refining diagnostic serotyping to detect pandemic strains of *S. enterica* ser Enteritidis. Jean Guard-Petter. 1998. Variants of smooth *Salmonella enterica* serovar Enteritidis that grow to higher cell density than the wild type are more virulent. Appl. Environ. Microbiol. 64:2166-2172. American Soc. for Microbiology (ASM), S.E. Branch Meeting, Montgomery, Alabama. Symposium on emerging human disease: The specialized virulence of *Salmonella enterica* serovar Enteritidis. Oct. 1998.

PUBLICATIONS: 1998/01 TO 1998/09

HOGUE, A., WHITE, P., GUARD-PETTER, J., SCHLOSSER, W., GAST, R.K., et al.
1998. Invited Review Article: Epidemiology and control of egg-associated S.E. in the U.S. Rev. Sci. et Tech., Intl Office of Epizootics 16:542-553.

ACCESSION NO: 0161480 SUBFILE: CRIS
PROJ NO: IND073058V AGENCY: CSREES IND
PROJ TYPE: ANIMAL HEALTH PROJ STATUS: TERMINATED
START: 01 OCT 1993 TERM: 30 SEP 1998 FY: 1998

INVESTIGATOR: PORTER, R. E.; BOWERSOCK, T. L.

PERFORMING INSTITUTION:
VET SCIENCE & ANIMAL DISEASE DIAGNOSTIC LAB
PURDUE UNIVERSITY
WEST LAFAYETTE, INDIANA 47907

ORAL VACCINATION OF CHICKENS WITH HYDROGELS TO PROMOTE RESISTANCE TO ENTERIC SALMONELLA ENTERITIDIS

OBJECTIVES: To stimulate systemic and mucosal immunity in chickens by oral vaccination with hydrogels; to determine whether a defined oral vaccination regimen with SE flagellin-hydrogels can promote resistance of the intestine to colonization and invasion by *Salmonella enteritidis*.

APPROACH: Hydrogels containing flagellin of *Salmonella enteritidis* will be orally administered to white leghorn chickens. The dose regimen will be varied to determine what regimen promotes the greatest humoral, mucosal, and cellular immune responses. Alimentary fluid and serum will be analyzed for IgA and IgG anti-SE activity by ELISA. Cell-mediated immunity will be measured by delayed-type hypersensitivity of the toeweb to intradermal injection of purified protein subunits of SE, such as flagellin or fimbriae. In an additional study, a defined oral vaccination regimen of hydrogels containing flagellin will be administered to chickens. Two weeks later the chickens will be

infected with *Salmonella enteritidis* phage type 13. At one week after infection chickens will be euthanized and cecum, colon, liver, and spleen will be cultured for *Salmonella enteritidis* to determine the effect of the vaccine.

PROGRESS: 1993/10 TO 1998/09

Vaccination of poultry against various infectious disease etiologies using parenteral routes is cumbersome and costly because it involves handling the birds during the vaccination process. This can be associated with significant stress which may compromise the immune status of the birds. We have started the evaluation of the Alginate hydrogels as carrier particles for *Salmonella enteritidis* proteins that may offer protection to the hens against natural infection with these organisms. We evaluated several lectins from: *Arachis hypogea*, *Conavalia ensiformis*, *Lens culinaris*, *Ricinus communis*, *Triticum esculentum* (wheat germ lectin) and *Triticum vulgaris*. These lectins were conjugated with Fluoresin isothiocyanate before oral administration into the White Leghorn hens. Results of these experiment suggested that there are specific pattern of attachment and engulfment of these lectins by the different parts of the alimentary tract of the hens. These results suggested the heterogenous composition of the villus epithelium of the alimentary tract in chickens. Wheat germ lectin was found to be the best stimulant when used to coat the Hydrogel particles uptake by the intestinal and liver and spleen tissues of the hens. The mean diameter of less than 5 microns appeared to be optimal in the tissue uptake of these microspheres.

PUBLICATIONS: 1993/10 TO 1998/09

1. T. L. Bowersock, K. Park, R.E. Porter, Jr. 1997. Patent No. 08-394, 802 awarded 9/97. Alginate based vaccine composition
2. R. E. Porter, Jr, N.P. Macri, T.L. Bowersock. 1997. Uptake of alginate microspheres by the intestinal tract of white leghorn chickens. Proceedings of the North Central Avian Disease Conference, Des Moines, IA., p.11-12.

Termination Year 1997

ACCESSION NO: 0169155 SUBFILE: CRIS

PROJ NO: PENV-9503113 AGENCY: CSREES PENV

PROJ TYPE: NRI COMPETITIVE GRANT PROJ STATUS: TERMINATED

CONTRACT/GRANT/AGREEMENT NO: 95-37201-2007

START: 15 SEP 1995 TERM: 30 SEP 1997 FY: 1998 GRANT YR: 1995

INVESTIGATOR: KELLER, L. H.

PERFORMING INSTITUTION:

PATHOBIOLOGY

NEW BOLTON CENTER

KENNETT SQUARE, PENNSYLVANIA 19348

IMMUNE RESPONSE TO SALMONELLA ENTERITIDIS COLONIZATION OF 2 MHC-CONGENIC LINES OF CHICKENS

OBJECTIVES: This laboratory has previously identified two MHC-congenic lines of White Leghorn chickens that respond differentially to an oral challenge with *S. enteritidis*. The project will examine the role of the immune response in this differential susceptibility in 2 day old and 5 day old chicks from these lines. The study will also determine the effect of the MHC locus differences on the shed of *S. enteritidis* into the eggs of adult laying hens from these two lines of chickens, and the involvement of the immune response in that shed. Therefore, the objectives of this project are to: (1) define immune cell populations that respond to *S. enteritidis* infection of neonatal chicks from the MHC-congenic lines, G-B1 and G-B2. (2) Compare *S. enteritidis* tissue colonization and shed into the eggs between the adult G-B1 and G-B2 laying hens. (3) Define immune cell populations that relate to *S. enteritidis* colonization of tissues and eggs from adult G-B1 and G-B2 laying hens.

APPROACH: Objective 1 will be carried out by isolation of intestinal intra-epithelial or lamina propria lymphocytes, and lymphoid cells from the spleen, cecal tonsils from chicks infected with *S. enteritidis* at either 2 or 5 days of age. Subtype specificities of the immune cell populations responding to *S. enteritidis* challenge will be compared with the specificities of immune cell populations in naive chickens by flow cytometric analysis after staining isolated lymphoid cells with avian immune-cell-specific monoclonal antibodies. Tissue samples will be taken 24, 72, 120 and 144 hours post-infection (pi). Objective 2 will be accomplished through bacterial culture for *S. enteritidis* isolation of tissues from the liver, spleen, intestine, ovary and oviduct, including eggs both pre-and post-oviposition, from infected and un-infected adult G-B1 and G-B2 laying hens. Objective 3 will utilize adult G-B1 and G-B2 laying hens, who will be inoculated with *S. enteritidis* at 24 weeks of age to compare immune cell populations that may relate to a differential shed of the pathogen into eggs. The same methods as described under objective 1 will be employed except the immune cell populations will also be identified from the oviduct and the cloaca of these hens.

Termination Year 1996

ACCESSION NO: 0174233 SUBFILE: CRIS
PROJ NO: PENV-5-24358 AGENCY: CSVM PENV
PROJ TYPE: STATE PROJ STATUS: NEW
START: 01 JAN 1996 TERM: 31 DEC 1996 FY: 1998

INVESTIGATOR: KELLER, L.

PERFORMING INSTITUTION:
SCHOOL OF VETERINARY MEDICINE
UNIV OF PENNSYLVANIA
PHILADELPHIA, PENNSYLVANIA 19104

SHED OF S. ENTERITIDIS INTO THE EGGS OF SUSCEPTIBLE AND RESISTANCE CHICKENS

OBJECTIVES: To compare the shed of S. enteritidis into the eggs of adult hens from two MHC-congenic lines of chickens with differential susceptibility to the pathogen and to monitor antibody titers and examine phagocytic cell functions that may relate to the differential response to S. enteritidis of the two MHC-congenic lines of chickens.

APPROACH: One-hundred twenty chickens from lines G-B1 and G-B2 will be used. At 3 days of age the chicks will be orally inoculated with organisms of the invasive strain of 575 S. enteritidis. Males will be culled within 10 weeks. As the matured hens begin to lay, their eggs will be collected daily. The eggs will be tested by bacteriology for the presence of S. enteritidis contamination for up to 12 months. Serum blood samples will be taken from the chickens every week for 1 month post-inoculation and every 2 weeks thereafter to test for anti-Salmonella antibody titers. Samples of egg yolks will be taken from each freshly laid egg as it is cracked for culturing. Yolk samples will be pooled in groups of 10 for ELISA testing.

ACCESSION NO: 0165256 SUBFILE: CRIS
PROJ NO: LAB03087 AGENCY: SAES LA.B
PROJ TYPE: STATE PROJ STATUS: TERMINATED
START: 01 JUL 1994 TERM: 31 DEC 1996 FY: 1997

INVESTIGATOR: LOE, L. C.; INGRAM, D. R.

PERFORMING INSTITUTION:
CALHOUN RESEARCH STATION
LOUISIANA STATE UNIVERSITY
BATON ROUGE, LOUISIANA 70893

EVALUATION OF MOLTING PROGRAMS FOR LAYING HENS

OBJECTIVES: Evaluate the effectiveness of molting programs on subsequent egg production and egg shell quality in laying hens.

APPROACH: Six molting treatments will be examined: 1) control (no treatment); 2) 10-day fast; 3) 4-day fast; 4) feeding 150,000 ppm zinc for 10 days; 5) feeding 150,000 ppm zinc for 4 days; 6) fasting hens until they achieve a 30% body weight loss. 240, 72-week old hens will be subjected to 7 days of 24 hour photostimulation prior to the start of the study. Egg production, egg specific gravity, egg weight, feed consumption, and livability will be measured during the treatment period and for 9, 28-day periods.

PROGRESS: 1994/01 TO 1996/12

Feed withdrawal (FW) and .15% dietary zinc (ZN) were evaluated for inducing molting laying hens. Six treatments (trt) included: 1) control- no FW or ZN (CON); 2) 4-day FW (4FW); 3) 10-day FW (10FW); 4) 4-day ZN (4ZN); 5) 10-day ZN (10ZN); and 6) feed withdrawal until a 30% loss in body weight was achieved 14-18 days (30BW). Each trt was applied to ten, individually cages hens, 74 wks old. The experiment had 4 replicates. Seven days prior to trt application, photoperiod was increased from 18L:6D to 24L:OD. Photoperiod was reduced to 17L:7D at trt initiation and was maintained at this level for the duration of the study. During the molt period, ZN trt proved inhibitory to feed consumption. No differences between FW and ZN trt of the same length were noted for days to pause, number of shell-less eggs or time to 50% production. Increasing length of molt trt increased hen weight loss and days to 50% production. Cumulative feed consumption per hen (36 wk post trt) was affected in a like manner. Hen weight at the end of the study was the same. No differences in cumulative production indices were found (egg production, egg weight, egg specific gravity, and feed efficiency) although initial trt effects were noted.

PUBLICATIONS: 1994/01 TO 1996/12

Loe, Linda C. and LeRon Robbins. 1996. Evaluation of dietary zinc or fasting in molting laying hens. Louisiana Academy of Sciences 70th Annual Meeting. (Poster presentation).

REVIEW OF THE LITERATURE

SALMONELLA, OTHER PATHOGENS, AND IMMUNOLOGY

Alodan MA; Mashaly MM (1999). **Effect of induced molting in laying hens on production and immune parameters.** *Poultry Science* 78(2): 171-177.

The Pennsylvania State University, University Park, PA.

NAL Call Number: 47.8 Am33P

A total of 600 commercial strain (DeKalb) Single Comb White Leghorn hens, 80 wk of age, were used in this study to determine the effects of different induced molting programs on production and immune parameters. The hens were randomly divided into four treatment groups (three experimental and one control) of 150 hens each. The hens in the first treatment group were fed a layer ration containing 20,000 ppm of zinc for 5 d, and received a reduced photoperiod of 8 h/d for 5 d (Zn group). In the second group, feed was withdrawn for 10 d, the photoperiod was reduced to 8 h/d and oyster shell and water were provided for ad libitum consumption. At Day 11, hens consumed corn and oyster shell ad libitum until Day 30 and at Day 31, hens were returned to a full feed layer ration and received 16 h of light/d [California treatment (CAL group)]. In the third treatment, light was reduced to 8 h/d, and oyster shell was provided for ad libitum consumption until Day 60. Feed and water were removed for the first 2 d and on Days 4, 6, and 8. On Days 3, 5, 7, and 9, hens were fed 45 g of feed per hen. On Day 10 until Day 60, hens were fed 90 g/hen and at Day 61, hens were returned to the layer ration ad libitum and received 16 h of light/d [on-again, off-again program (ON-OFF group)]. The last group served as controls (CONT). Body weight, egg production, egg size, internal egg quality, shell weight, and mortality were determined. Total circulating leukocytes, differential leukocyte counts, and antibody production were also measured. The results demonstrated that induced molting significantly increased egg production from 64% to 77 to 83%, Haugh units from 80.4 to 85.9 to 87.3, and shell weight from 5.3 g to 6.3 to 6.4 g when compared to CONT. The body weight of the molted hens decreased significantly to 84.8, 74.5, and 88% of the initial body weight for Zn, CAL, and ON-OFF groups, respectively. The total circulating leukocytes was significantly lower in molted hens than in CONT hens. Differential leukocyte counts were affected by all induced molting programs and the heterophil to lymphocyte ratio was significantly increased, reaching 0.61, whereas that of CONT was only 0.20. Antibody production was largely unaffected by any of the induced molting programs.

Descriptors: hens, molting, zinc, mineral supplements, photoperiod, restricted feeding, maize, oyster shells, refeeding, body weight, blood picture, ratios, leukocyte count, weight losses, laying performance, egg weight, egg shell, weight, egg quality, antibody formation, mortality, heterophil lymphocyte ratio

Al-Rawashdeh OF; Gumaa AY; Saeed M; Orban JI; Patterson JA; Nour AYM (2000). **Effects of sucrose thermal oligosaccharide caramel and feed restriction on the performance, hematological values and cecal bacteriological counts of broiler chickens.** *Acta*

Veterinaria (Beograd) 50(4): 225-239.

Faculty of Veterinary Medicine, University of Science and Technology, Irbid, Jordan.

NAL Call Number: 41.8 V6447

Inclusion of fructo-oligosaccharide in poultry diets and feed restriction are some of the strategies that have received increased attention in efforts to improve production efficiency and reduce mortality and *Salmonella* colonization in broiler chickens. Forty-eight 3-week-old Peterson x Arbor Acres males were used in an experiment to evaluate the influence of the novel sugar sucrose thermal oligosaccharide caramel (STOC) on haematological values and caecal total Gram-negative counts in growing broilers fed ad libitum or restricted diets. Broilers fed STOC consumed more feed, gained more weight ($P < 0.001$) and had a similar feed conversion compared with birds on the control diet. Birds fed ad libitum consumed more feed and gained more ($P < 0.001$) weight compared with birds fed the restricted diet. Chickens fed STOC had slightly but not significantly higher ($P > 0.05$) MCV, heterophil counts, H/L ratio and basophils than chickens fed the control diet. Feed-restricted birds had slightly higher PCV, MCV, WBC, heterophils, lymphocytes and monocytes than birds fed ad libitum. Six-week-old birds had slightly but not significantly higher values for PCV, RBC, MCV, WBC, lymphocytes and basophils. Packed cell volume (PCV) was lower for 4-week-old birds and tended to increase up to 6 weeks of age. In 8-week-old-birds fed STOC ad libitum there were lower lymphocyte counts and a higher H/L ratio compared with the control group. Although diet did not influence caecal Gram-negative bacterial counts (\log_{10}), the results indicate a significant decrease in \log_{10} bacterial counts in birds fed the restricted diets. Birds fed STOC had slightly less caecal Gram-negative bacteria than the control group. Caecal Gram-negative bacteria were influenced by age in broilers. Eight-week-old birds had lower mean \log_{10} bacterial counts in their caeca than 6-week-old birds. The results showed only slight alterations in haematological profile in broilers due to the influence of STOC and feed restriction. The observation of reduced numbers of Gram-negative bacteria in birds fed STOC with feed restriction needs further investigation.

Descriptors: oligosaccharides, heat treatment, processing, caramel, restricted feeding, haematology, caecum, intestinal microorganisms, pathogens, Gram negative bacteria, feed supplements, poultry

Alshawabkeh K; Tabbaa MJ (2002). **Using dietary propionic acid to limit *Salmonella gallinarum* colonization in broiler chicks.** *Asian-Australasian Journal of Animal Sciences* 15(2): 243-246.

NAL Call Number: SF55.A78A7

Descriptors: chicks, broilers, propionic acid, feed additives, *Salmonella gallinarum*, experimental infections, inhibitors, dosage, digesta, crop, cecum, pH, bacterial count, intestinal microorganisms

Ambrus SA; Tellez G; Hargis BM; Corrier DE; Deloach JR (1992). **Resistance to cecal *Salmonella-enteritidis* (SE) colonization following dietary lactose or capsaicin administration is associated with histopathological and morphometric changes of the cecal mucosa in leghorn chicks.** *Poultry Science* 71(Suppl.1): 135.

NAL Call Number: 47.8 Am33P

Arnold JW; Holt PS (1996). **Cytotoxicity in chicken alimentary secretions as measured by a derivative of the tumor necrosis factor assay.** *Poultry Science* 75(3): 329-334.

USDA, ARS, Poultry Processing and Meat Quality, Russell Research Center, Athens, GA.
NAL Call Number: 47.8 Am33P

The host immune response to enteric bacterial infections, including salmonellosis, results in inflammatory cells entering the intestine near the site of infection. These cells produce factors, such as cytokines, that are cytotoxic to bacteria-infected cells, resulting in loss of host cells. In this study, an assay was developed, based on the tumor necrosis factor (TNF) assay, that measured the cytotoxic activity in alimentary secretions from chickens during a *Salmonella enteritidis* (SE) infection. Secretions were collected by pilocarpine-induced evacuation from the alimentary tract and clarified by centrifugation. Activity was assessed by the cytotoxic effect of secretions on chicken embryo fibroblasts as target cells. Cytotoxic activity from SE-infected hens was measured at intervals during the first 24 h following infection and daily for the next 10 d. The level of activity varied between hens but was maximal in secretions obtained at 24 h and 10 d after SE infection. Maximal levels of cytotoxic activity in alimentary secretions from hens occurred in response to a dose of 5×10^8 cfu/mL of SE. The cytotoxicity in secretions from SE-exposed hens that were deprived of feed was greater than those from control SE-exposed hens by more than fivefold. Descriptors: chickens, salmonella enteritidis, cytotoxicity, inflammation, intestines, secretions, molting, bioassays, tumor necrosis factor, experimental infections

Bailey JS; Blankenship LC; Cox NA **Effect of fructooligosaccharide on *Salmonella* colonization of the chicken intestine.** *Poultry Science* 70(12): 2433-2438.

USDA, ARS, Russell Research Center, Athens, GA
NAL Call Number: 47.8 AM33P

The influence of fructooligosaccharide (FOS) on the ability of *Salmonella typhimurium* to grow and colonize the gut of chickens was investigated. In vitro studies showed that *Salmonella* did not grow when FOS was the sole carbon source. When FOS was fed to chicks at the .375% level, little influence on *Salmonella* colonization was observed. At the .75% level 12% fewer FOS-fed birds were colonized with *Salmonella* compared with control birds. When chicks given a partially protective competitive exclusion (CE) culture were fed diets supplemented with .75% FOS, only 4 of 21 (19%) chickens challenged with 10^9 *Salmonella* cells on Day 7 became colonized as compared with 14 of 23 (61%) chickens given CE alone. When chickens were stressed by feed and water deprivation on Day 13 and challenged with 10^9 *Salmonella* on Day 14, 33 of 36 (92%) chickens fed a control diet were colonized compared with only 9 of 36 (25%) chickens fed a .75% FOS diet. Chickens treated with FOS had a fourfold reduction in the level of *Salmonella* present in the ceca. Feeding FOS in the diet of chickens may lead to a shift in the intestinal gut microflora, and under some circumstances may result in reduced susceptibility to *Salmonella* colonization. Descriptors: fowls, salmonella typhimurium, colonizing ability, oligosaccharides, oral administration, competitive ability, stress response, feed additives, competitive exclusion

Barnhart ET; Caldwell DJ; Crouch MC; Byrd JA; Corrier DE; Hargis BM (1999). **Effect of lactose administration in drinking water prior to and during feed withdrawal on *Salmonella* recovery from broiler crops and ceca.** *Poultry Science* 78(2): 211-214.

Department of Poultry Science, Texas Agricultural Experiment Station, College Station, Texas 77843

NAL Call Number: 47.8 Am33P

Salmonella contamination of the chicken crop has been reported to increase markedly and significantly during feed withdrawal, probably due to coprophagy, and may contribute to carcass contamination at processing. The effect of prolonged lactose administration (2.5%) in the drinking water on the incidence of *Salmonella* recovery from broiler crops or ceca was evaluated in seven experiments. In these experiments, all or a percentage (providing seeders and contacts) of 7-wk-old broilers were challenged with approximately 1×10^8 cfu *Salmonella enteritidis* and provided lactose for 5 or 11 d prior to and during an 18 or 24 h feed withdrawal period. A small but significant lactose-mediated reduction in *Salmonella* contamination of crops was observed in one of two identical experiments with 18 h feed withdrawal. Extending the feed withdrawal period to 24 h did not improve the ability of lactose to affect *Salmonella* recovery from crops or ceca. Similarly, lactose did not affect *Salmonella* recovery when the percentage of birds challenged was reduced to 3 out of 16 and *Salmonella* recovery from crops or ceca of unchallenged, contact broilers was measured. Extending the duration of exposure to 2.5% lactose in the drinking water from 5 to 11 d did not improve the ability of lactose to affect *Salmonella* recovery. Taken together, these data suggest that provision of 2.5% lactose in the drinking water during the last 5 to 11 d of growout prior to slaughter will not be useful in an integrated *Salmonella* control program under commercial conditions.

Descriptors: *Chickens--microbiology--MI; *Lactose--pharmacology--PD; **Salmonella* --isolation and purification--IP ; Animal Husbandry--methods--MT;

Cecum--microbiology--MI; Chickens --physiology--PH; Crop, Avian--microbiology--MI; Drinking; Food Contamination--prevention and control--PC; Food Deprivation; Lactose --administration and dosage--AD; *Salmonella*--pathogenicity--PY

Barua A; Furusawa S; Yoshimura Y; Okamoto T (2001). **Effects of forced molting on the IgY concentration in egg yolk of chickens.** *Japanese Poultry Science* 38(2): 169-174.

Hiroshima Univ., Higashi-hiroshima, Japan

NAL Call Number: 47.8 N57

Descriptors: laying hen, yolk, immunoglobulin, rearing management, restricted feeding, molting, ELISA, immunoglobulin Y, forced molting, IgY concentration is increased during early phase of postmolt

Berchieri A Jr; Murphy CK; Marston K; Barrow PA (2001). **Observations on the persistence and vertical transmission of *Salmonella enterica* serovars *Pullorum* and *Gallinarum* in chickens: effect of bacterial and host genetic background.** *Avian Pathology* 30(3): 221-231.

NAL Call Number: SF995.A1A9

Commercial laying hens inoculated with a strain of *Salmonella enterica* ser. Pullorum when they were 4 days old showed no morbidity, but harboured infection until they came into lay, and then produced *S. Pullorum*-contaminated eggs and infected progeny. There was limited evidence of transmission of maternal immunity to the progeny. Attempts were made to set up similar infections in hens with *Salmonella Gallinarum*, but without success. Infection either resulted in clinical disease or elimination of the pathogen. Infection of birds when in lay produced a similar result. The possibility of eggs becoming contaminated with *S. Gallinarum* after they were laid in the nest box was evaluated but there was no evidence for this. In-bred chicken lines with a *SalI*-susceptible phenotype showed greater localization of *S. Pullorum* in the reproductive tract than did a *SalI*-resistant line. In addition, in-bred birds, which were *SalI* resistant but showed greater susceptibility to intestinal colonization by *Salmonella*, infected with *S. Gallinarum* when they were 1 week old, showed longer term persistence in the liver and spleen than did a resistant line.

Descriptors: hens, *Salmonella pullorum*, *Salmonella gallinarum*, microbial contamination, eggs, chicks, vertical transmission, persistence, liver, spleen, maternal immunity, line differences, susceptibility, genetic-resistance

Berchieri A. Jr.; Wigley P; Page K; Murphy CK; Barrow PA (2001). **Further studies on vertical transmission and persistence of *Salmonella enterica* serovar Enteritidis phage type 4 in chickens.** *Avian Pathology* 30(4): 297-310.

NAL Call Number: SF995.A1A9

One-week-old commercial layers were infected orally with 10(8) colony forming units of *Salmonella enterica* serovar Enteritidis phage type 4. No mortality was observed. The inoculated organism was isolated in decreasing viable numbers from a number of tissues, particularly the spleen, liver and caeca. Organisms present in the spleen were primarily localized within macrophages. No *Salmonella* Enteritidis organisms were isolated between 10 and 24 weeks of age, when the experiment was terminated after several weeks of lay. When two groups of adult hens, housed with males, were infected, contaminated eggs were found within 2 weeks of infection in one of the experiments only. Progeny hatched from these eggs showed no mortality unless they were infected artificially with the *S. Enteritidis* strain. In this case, the percentage mortality fell as the hatches progressed, indicating increasing immunity to infection. The faecal excretion of the inoculated phage type 4 strain by infected but healthy progeny was followed. Although most birds ceased to excrete by 11 to 12 weeks of age, a small number of the birds continued to excrete until they themselves came into lay. The small numbers of birds in which this occurred indicates that tolerance to infection does not occur readily following infection of hens laying fertile eggs or in progeny birds infected before or within hours of hatching. Birds infected when they were less than 24 h old remained persistently infected until they were well into lay. However, control birds infected when 1 week old, on this occasion, showed a high level of excretion until the birds began to lay at 18 weeks. Inbred lines of chickens showing differences in their susceptibility to systemic salmonellosis did not show significant differences in the extent to which *S. Enteritidis* localized in the organs of the reproductive tract or in the number of infected eggs produced.

Descriptors: chickens, *Salmonella enteritidis*, vertical transmission, persistence, macrophages, experimental infections, eggs, microbial contamination, mortality, maternal immunity, chicks, genotypes, susceptibility, age

Bhatia TR; McNabb GD (1980). **Dissemination of *Salmonella* in broiler-chicken operations.** *Avian Diseases* 24(3): 616-624.

NAL Call Number: 41.8 Av5

Dissemination of *Salmonella* from hatchery to broiler farm and from broiler farm to processing plant was assessed. Bacteriological examination of fluff and meconium at the hatchery, feed and litter at the farm, and carcass rinsing at the plant level was conducted. When fluff and/or meconium were contaminated with *Salmonella*, litter and carcasses were contaminated with the same serotypes. Properly pelleted feed does not seem to be an important source of infection. Stress (feed and water deprivation) and some effect on shedding of *Salmonella*. Fluff and meconium at hatchery, feces from 3-to-7-day-old chicks, and litter at 3 and 6 weeks can be used as an indicator of flock infection and thus carcass contamination.

Descriptors: *Chickens--microbiology--MI; **Salmonella*--isolation and purification--IP ; Animal Feed; Animal Husbandry; Feathers--microbiology--MI; Food Microbiology; Food-Processing Industry; Manure; Meat; Meconium --microbiology--MI; *Salmonella typhimurium*--isolation and purification

Bierer BW; Eleazer TH (1965). **Clinical salmonellosis accidentally induced by feed and water deprivation of one-week-old broiler chicks.** *Poultry Science* 44(6): 1606-1607.

NAL Call Number: 47.8 Am33P

Descriptors: *Poultry Diseases; **Salmonella* Infections, Animal--etiology--ET; *Starvation

Branton SL; May JD; Lott BD; Pharr GT (1999). **Effects of age at inoculation and induced molt on the recovery of *Mycoplasma gallisepticum* from layer chickens.** *Avian Diseases* 43(3): 516-520.

USDA, ARS, South Central Poultry Research Laboratory, Mississippi State.

NAL Call Number: 41.8 Av5

An experiment was conducted to determine the effects of age at inoculation and induced molt on the reisolation of *Mycoplasma gallisepticum* (MG) from commercial leghorn hens that had been eyedrop-inoculated with F strain MG at either 10 or 66 wk of age. Chickens were maintained in biological isolation units from 10 wk of age through 78 wk of age. At 70 wk of age (premolt), hens were swabbed, cultured for MG, and molted. Swabs were taken both at the end of molt (postmolt [74 wk]) and again 4 wk later (postmolt + 4 [78 wk]). A significant (P less than or equal to 0.05) decrease in MG isolations was observed in the postmolt swabs as compared with the premolt swabs of hens inoculated at either 10 or 66 wk of age. A significant (P less than or equal to 0.05) increase in isolations was observed in the postmolt + 4 swabs as compared with the postmolt swabs of hens inoculated at either 10 or 66 wk of age. For the hens inoculated at 10 wk, no significant difference was found in premolt as compared with postmolt + 4 MG isolations; however, for hens inoculated at 66 wk, a significant (P less

than or equal to 0.05) decrease was observed between premolt and postmolt + 4 isolations. Significantly (P less than or equal to 0.05) fewer MG isolations were obtained from the premolt swabs of hens inoculated at 10 wk as compared with hens inoculated at 66 wk. No significant difference in MG isolations was observed in either the postmolt or postmolt + 4 swabs between hens inoculated at either 10 or 66 wk.

Descriptors: chickens, mycoplasma gallisepticum, age, vaccination, molt, persistence

Branton SL; Simmons JD; Hardin JM (1989). **The effect of biological isolation and a molt-inducing regimen on the recovery of *Mycoplasma gallisepticum* from commercial Leghorn hens.** *Avian Diseases* 33(3): 574-577.

USDA, ARS, South Central Poultry Research Laboratory, Mississippi State, Mississippi
NAL Call Number: 41.8 Av5

Two trials were conducted to determine the effect of induced molt on the reisolation of *Mycoplasma gallisepticum* (MG) from commercial leghorn hens that had been eyedrop-inoculated with MG at 10 weeks of age. Chickens were maintained in a conventional floored chicken house on dry litter through 100 weeks of age. At age 64 weeks, 4 days (Trial 1), and at 100 weeks (Trial 2), hens were swabbed and cultured for MG and then molted in biological isolation units. Swabs were again taken at the end of each molt. No difference was observed in the number of MG isolations between molted hens and controls that did not undergo molting. However, a significant decrease in MG isolations was observed in both trials from swabs obtained when hens were housed on dry litter floors as compared with swabs taken from the same hens after 18 days (Trial 1) or 21 days (Trial 2) of confinement in isolation units.

Descriptors: Chickens--microbiology--MI; Mycoplasma--isolation and purification--IP; Mycoplasma Infections--veterinary--VE; Poultry Diseases--microbiology--MI ; Age Factors; Chickens--physiology--PH; Housing, Animal; Mycoplasma Infections--microbiology--MI

Byrd JA; Corrier DE; Hume ME; Bailey RH; Stanker LH; Hargis BM (1998). **Effect of feed withdrawal on *Campylobacter* in the crops of market-age broiler chickens.** *Avian Diseases* 42(4): 802-806.

USDA, ARS, Food Animal Protection Research Laboratory, College Station, Texas
NAL Call Number: 41.8 Av5

The presence of *Campylobacter* and *Salmonella* on poultry meat products remains a significant public health concern. Previous research has indicated that feed withdrawal may significantly increase *Salmonella* contamination of broiler crops and that crop contents may serve as an important source of *Salmonella* carcass contamination at commercial processing. The present study evaluated the effect of preslaughter feed withdrawal on the incidence of *Campylobacter* isolation in crops of market-age commercial broiler chickens prior to capture and transport to the processing plant. The incidence of *Campylobacter* isolation from the crop was determined immediately before and after feed withdrawal in 40 7-wk-old broiler chickens obtained from each of nine separate broiler houses. Ceca were collected from broilers in six of the same flocks for comparison with the crop samples. Feed withdrawal caused a significant ($P < 0.025$) increase in *Campylobacter*-positive crop samples in seven of

the nine houses sampled. Furthermore, the total number of *Campylobacter*-positive crops increased significantly ($P < 0.001$) from 90/360 (25%) before feed removal to 224/359 (62.4%) after the feed withdrawal period. Alternatively, feed withdrawal did not significantly alter the *Campylobacter* isolation frequency from ceca. Similar to our previous studies with *Salmonella*, the present results suggest that preharvest feed withdrawal increases the frequency of *Campylobacter* crop contamination and, thus, provides a source of *Campylobacter* contamination of carcasses at commercial processing.

Descriptors: broilers, campylobacter, food deprivation, crop, food safety, contamination, carcasses, incidence, cecum

Corrier DE; Byrd JA; Hargis BM; Hume ME; Bailey RH; Stanker LH (1999). **Survival of *Salmonella* in the crop contents of market-age broilers during feed withdrawal.** *Avian Diseases* 43(3): 453-460.

USDA, ARS, Food Animal Protection Research Laboratory, College Station, Texas
NAL Call Number: 41.8 Av5

Recent studies have indicated that crop contamination increases during preslaughter feed withdrawal and that contaminated crop contents may serve as an important source of *Salmonella* entry into poultry processing plants. During the present study, we evaluated the effect of preslaughter feed withdrawal on crop pH and *Salmonella* crop contamination in broilers from three commercial broiler flocks. The effect of experimental feed withdrawal on crop pH, lactic acid concentration, and *Salmonella* crop contamination was also evaluated in market-age broilers challenged experimentally with *Salmonella typhimurium*. Crop pH increased significantly ($P < 0.05$) from 3.64 ± 0.25 before feed removal to 5.14 ± 0.72 after 8 hr of feed withdrawal in broilers from commercial flocks. The incidence of *Salmonella* crop contamination in the commercial broilers increased ($P < 0.05$) from 3.3% before feed removal to 12.6% after 8 hr of feed withdrawal. Similarly, crop pH increased ($P < 0.05$) by a magnitude of approximately 1 unit in broilers after 8 hr of experimental feed withdrawal. The population of *S. typhimurium* in the crops of the experimentally challenged broilers increased ($P < 0.05$) by approximately 1 log unit during the 8-hr experimental feed withdrawal. The concentration of lactic acid in the crop of the broilers during experimental feed withdrawal decreased ($P < 0.01$) from a range of 119-135 micromol/ml before feed removal to a range of 22-32 micromol/ml after 8 hr of feed withdrawal. The results indicated that feed withdrawal resulted in a decrease in lactic acid in the crop, accompanied by an increase in crop pH, and an increase in *Salmonella* crop contamination.

Descriptors: broilers, salmonella, survival, crop, pH, food deprivation, microbial contamination, lactic acid, flocks

Corrier DE; Nisbet DJ; Hargis BM; Holt PS; DeLoach JR (1997). **Provision of lactose to molting hens enhances resistance to *Salmonella enteritidis* colonization.** *Journal of Food Protection* 60(1): 10-15.

ARS, Food Animal Protection Research Laboratory, USDA, College Station, TX.
NAL Call Number: 44.8 J824

Older leghorn hens, more than 50 weeks of age, were divided into three groups designated 1,

unmolted controls; 2, molted; or 3, molted treated with lactose. Forced molt was induced by 14 days of feed removal. Lactose was provided to the hens in group 3 as 2.5% (wt/vol) of the daily drinking water. Each hen in all groups was challenged orally with 10(5) *Salmonella enteritidis* (SE) cells on day 7 of feed removal. The study was repeated in three replicated trials. The concentrations of acetic, propionic, and total volatile fatty acids (VFA) in the cecal contents of the molted hens in groups 2 and 3 decreased significantly ($P < 0.05$) on days 6 and 14 of molt compared with the unmolted controls. Forced molt had no apparent effect on pH or on the oxidation-reduction potential of the ceca. Compared to the unmolted controls, SE cecal and spleen and liver colonization was significantly increased ($P < 0.05$) in the molted hens in group 2. Compared to the molted hens in group 2, SE cecal and spleen and liver colonization was significantly decreased ($P < 0.05$) in two of three trials in the hens in group 3 provided with lactose. The results suggested that the increased susceptibility of molting hens to SE colonization may be associated with decreased fermentation and production of VFA by cecal bacteria or by a depletion of the number of VFA-producing bacteria present in the ceca. The results further suggest that providing lactose in the drinking water during molting may significantly enhance resistance to SE colonization.

Descriptors: chickens, diet, lactose, salmonella enteritidis, disease resistance ;

Corrier DE; Nisbet DJ; Hargis BM; Kogut MH; Deloach JR (1995). **Protective effect of providing lactose to leghorn hens during molting on *Salmonella enteritidis* infection.** *Poultry Science* 74(Suppl. 1): 51.

Food Animal Protection Res. Lab., USDA-ARS, College Station, TX 77845 USA
NAL Call Number: 47.8 Am33P

Dorn CR; Silapanuntakul R; Angrick EJ; Shipman LD (1993). **Plasmid analysis of *Salmonella enteritidis* isolated from human gastroenteritis cases and from epidemiologically associated poultry flocks.** *Epidemiology and Infection* (ENGLAND) 111(2): 239-243.
Department of Veterinary Preventive Medicine, Ohio State University, Columbus 43210.
NAL Call Number: RA651 A1E74

Plasmid analysis of *Salmonella enteritidis* isolates from human gastroenteritis cases and from two commercial egg-producing poultry flocks was performed to determine if the poultry flocks were the source of the human infections. The plasmid profile and restriction fragment pattern (fingerprint) of five *S. enteritidis* isolates from human cases matched those of nine isolates from internal organs of egg-laying hens in one flock which was the source of eggs consumed by the cases. Another commercial flock was epidemiologically associated as the source of eggs consumed by affected persons in four separate gastroenteritis outbreaks from which *S. enteritidis* isolates were available. Five *S. enteritidis* isolates from human cases in these four outbreaks had the same profile and fingerprint, and they all matched those of the 24 isolates from hens in this flock. These results provide further documentation of egg-borne transmission of *S. enteritidis* to humans.

Descriptors: *Chickens--microbiology--MI; *Food Microbiology; *Gastroenteritis--microbiology--MI; *Salmonella Food Poisoning--microbiology--MI; *Salmonella enteritidis--genetics--GE ; DNA Fingerprinting; DNA, Bacterial--analysis--AN; Disease

Outbreaks; Eggs --microbiology--MI; Gastroenteritis--epidemiology--EP; Plasmids--genetics --GE; Polymorphism, Restriction Fragment Length; Salmonella Food Poisoning -

Durant JA; Corrier DE; Byrd JA; Stanker LH; Ricke SC (1999). **Feed deprivation affects crops environment and modulates *Salmonella enteritidis* colonization and invasion of Leghorn hens.** *Applied and Environmental Microbiology* 65(5): 1919-1923.

Texas A&M University, College Station, TX.

NAL Call Number: 448.3 Ap5

Leghorn hens over 50 weeks of age were assigned to two treatment groups designated as either unmolted controls or molted. A forced molt was induced by a 9-day feed withdrawal, and each hen was challenged orally with 10(5) *Salmonella enteritidis* organisms on day 4 of feed withdrawal. On days 4 and 9 of molt, the numbers of lactobacilli and the concentrations of lactate, acetate, propionate, and butyrate, and total volatile fatty acids in the crops decreased while crop pH increased significantly ($P < 0.05$) in the molted hens compared to the controls. *S. enteritidis* crop and cecal colonization, in addition to spleen and liver invasion, increased significantly ($P < 0.05$) in the molted hens compared to the controls. The invasive phenotype of *Salmonella* spp. is complex and requires several virulence genes which are regulated by the transcriptional activator HilA. Samples of the crop contents from the molted and unmolted birds were pooled separately, centrifuged, and filter sterilized. The sterile crop contents were then used to measure the expression of hilA. By using a lacZY transcriptional fusion to the hilA gene in *S. enteritidis*, we found that hilA expression was 1.6- to 2.1-fold higher in the crop contents from molted birds than in those from control birds in vitro. The results of the study suggest that the changes in the microenvironment of the crop caused by feed deprivation are important regulators of *S. enteritidis* survival and influence the susceptibility of molted hens to *S. enteritidis* infections. Furthermore, our in vitro results on the expression of hilA suggest that the change in crop environment during feed withdrawal has the potential to significantly affect virulence by increasing the expression of genes necessary for intestinal invasion.

Descriptors: transcription factors, gene expression

Durant JA; Corrier DE; Stanker LH; Ricke SC (2000). **Expression of the hilA *Salmonella typhimurium* gene in a poultry *Salmonella enteritidis* isolate in response to lactate and nutrients.** *Journal of Applied Microbiology* 89(1): 63-69.

Department of Poultry Science, Texas A & M University, College Station, TX 77843-2472

NAL Call Number: QR1 J687

Pathogens express virulence genes in response to the combination of environmental conditions present in the host environment. The crop is the first gastrointestinal environment encountered in birds. However, feed withdrawal alters the crop environment resulting in an increased pH, and decreased concentrations of lactate, glucose and amino acids compared with unmolted birds. *Salmonella enteritidis* infections increase significantly in hens that have been forced to moult by feed withdrawal. The effects of pH, carbohydrate sources, amino acids and lactate on expression of *S. enteritidis* virulence was investigated by measuring expression of hilA. The hilA gene encodes a transcriptional activator that regulates

expression of *Salmonella* virulence genes in response to environmental stimuli. *hilA* expression was measured using a poultry isolate of *S. enteritidis* carrying a *hilA-lacZY* transcriptional fusion from *S. typhimurium*. The media used were Luria Bertani (LB) broth and LB broth diluted 1:5 (DLB). The expression of *hilA* was 2.9-fold higher in DLB broth compared with LB broth which suggested that there is a nutritional component to the regulation of *hilA*. Addition of 0.2% glucose, fructose or mannose to LB and DLB reduced *hilA* expression 1.5- to 2-fold. Addition of 0.2% Casaminoacids, arabinose, fucose, or lactose had little effect on *hilA* expression. Lactate (25 and 50 mmol/litre) reduced *hilA* expression at pH 6, 5 and 4, with the lowest expression at pH 4. These results suggest that the composition of the crop lumen could potentially affect *S. enteritidis* virulence expression. Descriptors: nutrients; poultry; amino acids; arabinose; environment; fructose; digestive system; genes; lactates; mannose; nutrition; virulence; gene expression; in vitro culture; bacterial diseases

Ebel E; Schlosser W (2000). **Estimating the annual fraction of eggs contaminated with *Salmonella enteritidis* in the United States.** *International Journal of Food Microbiology* 61(1): 51-62.

NAL Call Number: QR115.I57

Descriptors: eggs, food contamination, microbial contamination, salmonella enteritidis, estimation, incidence, monte carlo method, epidemiology, flocks, prediction, risk assessment, mathematical models, molting, affected flocks

Fadly AM; Davison TF; Payne LN; Howes K (1989). **Avian leukosis virus infection and shedding in Brown Leghorn chickens treated with corticosterone or exposed to various stressors.** *Avian Pathology* 18(2): 283-298.

AFRC Inst. Anim Hlth., Houghton, Huntingdon, Cambridgeshire PE17 2DA, UK.

NAL Call Number: SF995.A1A9

Brown Leghorn chicks derived from hens positive for antibodies to subgroup A avian leukosis virus (MAB+) and chicks derived from virus-free hens (MAB-) were exposed to avian leukosis virus (ALV HPRS-F42 strain)-infected hens from hatching to 18 weeks of age. At one or two weeks of age some chicks were implanted with a pellet containing a mixture of corticosterone and cholesterol (1:4 w/w) or with an osmotic pump containing corticosterone dissolved in polyethylene glycol (PEG-400) which delivered 50 micro g/hour over 7 days. In a second trial implanted chicks were moved to climatic chambers at two weeks old and kept at 40 deg C or 25 deg C for 3 weeks, or at 15 deg C for 4 days and then at 10 deg C. In a third trial 38-week-old hens that had been inoculated with ALV as embryos, at one day old or at 4 weeks old and forced to moult by changes in photoperiod and food and water intakes were examined for egg production, plasma corticosterone and triiodothyronine. In a fourth trial these hens were implanted with osmotic pumps as above after return to lay (60 weeks old) and inoculated with ALV (1.6 x 10⁵ infectious units) by oral, nasal, ocular and tracheal routes. Samples of meconium, cloacal, and vaginal swabs and plasma were tested for ALV. Increased levels of plasma corticosterone following implantation of the hormone at 1, but not 2, weeks after exposure to ALV at hatching, increased cloacal shedding of ALV in chickens

that lacked maternal antibody (MAB-) to ALV. Exposure of 2-week-old chickens, which had been exposed to virus at hatching, to heat- or cold-stress for 21 days had no effect on ALV infection and shedding in treated as well as in control chickens. Induced moulting or raised circulating corticosterone in adult hens did not affect the incidence of ALV infection or shedding.

Descriptors: glucocorticoids, cold zones, heat, molting, stress

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Fernandez F; Hinton M; Gils B van (2002). **Dietary mannan-oligosaccharides and their effect on chicken caecal microflora in relation to *Salmonella enteritidis* colonization.** *Avian Pathology* 31(1): 49-58.

Division of Food Animal Science, Department of Clinical Veterinary Science, University of Bristol, Langford, Avon BS40 5DU, UK.

NAL Call Number: SF995.A1A9

This study first investigates the effects of mash diet, or mash supplemented with either 2.5% mannose-oligosaccharide (MOS) or palm kernel meal (PKM), on the microflora of the hen caecal contents. Second, it investigates the effect of caecal contents of hens (HCC) fed mash or mash supplemented with MOS or PKM on the major microflora groups of chicks, and their inhibitory effect on *Salmonella enterica* serovar Enteritidis (PT4) colonization. Finally, this study investigates the effect over time of diets supplemented with MOS or PKM on *S. Enteritidis* colonization and the microflora of chicks. In hens, supplemented diets increased *Bifidobacterium* spp., while decreasing members of *Enterobacteriaceae* and *Enterococcus* spp., compared with the mash diet. Chicks dosed with the HCC showed, on average, increased numbers of anaerobes, while the numbers of aerobes decreased including coliforms and *S. Enteritidis* compared with controls without HCC. In chicks fed the MOS-supplemented or PKM-supplemented diets, *S. Enteritidis* colonization decreased over time, compared with mash alone. Four-week-old PKM birds showed an increase in *Bifidobacterium* spp. and *Lactobacillus* spp., with a decrease in *S. Enteritidis* compared with week 2. Generally, the HCC and diets supplemented with MOS or PKM affected the birds intestinal microflora by increasing the *Bifidobacterium* spp. and *Lactobacillus* spp., while decreasing the *Enterobacteriaceae* groups. They also reduced susceptibility in young chickens to colonization by *S. Enteritidis*.

Descriptors: caecum, chicks, diets, hens, infection, mannans, microbial flora, oligosaccharides, palm kernel cake, poultry

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Furuta K (1); Mekada Hiroyuki (2); Hayashi N (2) (1991). **Detection of antibodies against pathogens and measurement of serum components of chickens which laying was paused by forced molting.** *Nippon Kakin Gakkaishi (Japanese Poultry Science)* 28(1): 47-51.

(1)Univ. of Ryukyus, College of Agriculture ; (2)Gifu Prefect. Poultry Exp. Stn.

NAL Call Number: 47.8 N57

Descriptors: molting, laying hen, antibody titer, enzyme activity, egg-laying, blood component, serum, alkaline phosphatase, GOT, GPT, pathogen, rearing management

Gast RK; Nasir MS; Jolley ME; Holt PS; Stone HD(2002). **Serologic detection of experimental *Salmonella enteritidis* infections in laying hens by fluorescence polarization and enzyme immunoassay.** *Avian Diseases* 46(1): 137-142.

United States Department of Agriculture, Agricultural Research Service, Southeast Poultry Research Laboratory, Athens, Georgia

NAL Call Number: 41.8 Av5

Detection of infected poultry flocks is essential for controlling eggborne transmission of *Salmonella enteritidis* to humans. The present study evaluated the detection of antibodies in the sera of experimentally infected chickens by a fluorescence polarization assay with a tracer prepared from the O-polysaccharide of *S. enteritidis* and an enzyme-linked immunosorbent assay (ELISA) with an *S. enteritidis* flagellin antigen. In two trials, groups of specific-pathogen-free laying hens were infected orally with either 10(6) or 10(8) colony-forming units (CFU) of *S. enteritidis* (phage type 13a) or with 10(8) CFU of *Salmonella typhimurium*. Serum samples were collected before inoculation and at five subsequent weekly intervals. Both assays successfully detected the majority of hens infected with *S. enteritidis* at either dose level, but they also identified a substantial number of hens infected with *S. typhimurium* as seropositive. The fluorescence polarization test detected *S. enteritidis* infection significantly more often and cross-reacted with sera from hens infected with *S. typhimurium* significantly less often than the ELISA. The fluorescence polarization assay also offered advantages in terms of speed and methodologic simplicity.

Gray JS (1982). **The effect of induced moulting in hens on resistance to primary and secondary infections of *Raillietina cesticillus* Molin, 1858.** *Journal of Helminthology* 56(1): 37-40.

NAL Call number: 436.8 J82

Mature hens induced to moult were subsequently found to be resistant to both primary and secondary infections of *Raillietina cesticillus*; non-moulting birds that continued to lay were susceptible to both.

Descriptors: resistance, host, immunity, reproduction, *Raillietina cesticillus* (Cestoda)

Hill CH (1989). **Effect of *Salmonella gallinarum* infection on zinc metabolism in chicks.** *Poultry Science* 68(2): 297-305.

Dep. Poultry Science, North Carolina State Univ., Raleigh, NC 27695-7608, USA.

NAL Call Number: 47.8 Am33P

The effect of *Salmonella gallinarum* infection in chickens on serum, liver and kidney zinc concentrations was studied. Within 48 h after intraperitoneal administration of *S. gallinarum*, serum Zn decreased to about one-half the control value. In one experiment, serum Zn remained low for the 12 days of the experiment, whereas in a second experiment, serum Zn gradually increased after 6 days postinoculation but never returned to the control value. Supplemental zinc 500 mg/kg did not prevent the infection-induced decrease in the serum Zn. The infection resulted in a sequestering of Zn in the liver; the kidney remained relatively unresponsive in this system. Fractionation of liver homogenates by gel filtration column chromatography revealed that the Zn in livers of infected animals eluted in a volume

characteristic of metallothionein, whereas that of controls was associated with high molecular weight proteins. Increasing serum Zn by repeated subcutaneous Zn injections had no effect on mortality. Restricting feed intake of uninfected chickens to that of infected chickens resulted in similar weight gains, but effects on metallothionein and serum Zn were minimal compared with effects in infected chickens.

Descriptors: zinc metabolism, infection, Salmonellosis, *Salmonella gallinarum*

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Holt PS (1999). **Impact of induced molting on immunity and *Salmonella enterica* serovar *Enteritidis* infection in laying hens.** In *Salmonella enterica* serovar *Enteritidis* in humans and animals: epidemiology, pathogenesis, and control, Saeed AM; Gast RK; Potter ME; Wall PG (eds.), Iowa State University Press: Ames, Iowa USA, p.367-375.

NAL Call Number: RA644 S15 S23 1999

Descriptors: moulting, immune response, hens, animal husbandry, disease transmission, poultry

Holt PS (1995). **Horizontal transmission of *Salmonella enteritidis* in molted and unmolted laying chickens.** *Avian Diseases* 39(2): 239-249.

USDA, ARS, Southeast Poultry Research Laboratory, Athens, GA.

NAL Call Number: 41.8 Av5

The impact of induced molting on the horizontal transmission of *S. enteritidis* was studied. In Expt. 1, every other hen in rows of either molted or unmolted hens was infected with *S. enteritidis* (1×10^6 bacteria/hen). *S. enteritidis* was transmitted more rapidly to the unchallenged hens in the adjacent cages of molted hens than in unmolted hens, and these molted hens shed significantly more of the organism than unmolted hens. In Expts. 2 and 3, the center hen in two rows each of 11 molted and unmolted hens was infected with *S. enteritidis* (dose of $6-8 \times 10^4$ in Expt. 2 and 1×10^3 in Expt. 3). In both trials of Expt. 2, the rate of transmission was significantly higher in molted hens than in unmolted hens, and the molted hens shed significantly more of the organism. In Trial 1 of Expt. 3, molting had little effect on *S. enteritidis* shedding. In Trial 2 of Expt. 3, however, molted hens had significantly higher shed rates and shed more *S. enteritidis* than the unmolted hens. Individual hens in Expts. 2 and 3 frequently shed more *S. enteritidis* than the original challenge. The amplification of intestinal *S. enteritidis* in the molted hens plus their previously described higher susceptibility to *S. enteritidis* infection accelerated transmission of the organism to the uninfected hens in neighboring cages. These results indicate that induced molting can have substantial effects on transmission of *S. enteritidis* to uninfected hens, which could affect the overall *S. enteritidis* status of a flock.

Descriptors: hens, salmonella enteritidis, disease transmission, spread, molting, susceptibility, food deprivation, induced molting

Holt PS (1993). **Effect of induced molting on the susceptibility of white leghorn hens to a *Salmonella enteritidis* infection.** *Avian Diseases* 37(2): 412-417.

NAL Call Number: 41.8 Av5

Older white leghorn hens (more than 52 weeks old) were induced to molt using a 14-day feed-removal protocol. On day 4 of feed removal, groups of hens were infected with varying 10-fold dilutions of *Salmonella enteritidis*, and these hens were examined for *S. enteritidis* intestinal shedding 7 days later. Molting hens infected with a 10⁻¹ dilution of *S. enteritidis* shed 3-4 logs more of the organism at 7 days postinfection than the unmolted group receiving a similar dose. The mean infectious dose (ID₅₀) for *S. enteritidis* in unmolted hens ranged from 0.65 X 10⁽⁴⁾ to 5.6 X 10⁽⁴⁾, whereas in molting hens the ID₅₀ was found to be less than 10¹, a 2-3 log increase in the susceptibility of the hens to the organism. Descriptors: hens, molting, induction, salmonella enteritidis, susceptibility, disease resistance, inoculum, experimental infection

Holt PS (1993). **Effect of induced molting on the susceptibility of chickens to *Salmonella enteritidis* infection.** *Poultry Science* 72(Suppl.1): 171.
USDA/ARS, Southeast Poultry Research Laboratory, Athens, GA 30605
NAL Call Number: 47.8 Am33P

Holt PS (1992). **Effect of induced on molting on B cell and CT4 and CT8 T cell numbers in spleens and peripheral blood of White Leghorn hens.** *Poultry Science* 71(12): 2027-2034.
USDA, ARS, Southeast Poultry Research Laboratory, Athens, Georgia
NAL Call Number: 47.8 AM33P

Two trials were conducted to examine the possible effect of induced molting on splenic and peripheral blood T and B cells. Molting was achieved using shortened light exposure and a 14-day fast. Feed was removed on Day 0 and blood for analysis was removed on Days 3, 10, and 17 whereas spleens were removed on Days 4, 11, and 18. Fluorochrome-labeled antichickens CT4 and CT8 monoclonal antibodies were used to examine molting effects on chicken T cells and polyclonal anti-chicken immunoglobulin was used to detect chicken B cells. The labeled cell preparations were analyzed by flow cytometry. Molted hens had significantly decreased CT4⁺ peripheral blood T cells on Day 3 in both trials and on Day 10 in one trial. No effects on peripheral blood CT8⁺ T cells were observed. Splenic CT4⁺ T cells were decreased on Day 11 in one trial whereas splenic CT9⁺ T cells were significantly increased on Day 4 in two trials and on Day 11 in one trial. Peripheral blood and splenic B cells were largely unaffected in both trials. These results indicate that fasting to induce a molt does alter T lymphocyte subpopulations and these effects primarily occur early in the fasting procedure.

Descriptors: hens, fasting, b lymphocytes, t lymphocytes, molting, spleen, blood, cell counting, flow cytometry, immunological deficiency

Holt PS (1992). **Effects of induced moulting on immune responses of hens.** *British Poultry Science* 33(1): 165-175.
US Department of Agriculture, Agriculture Research Service, Southeast Poultry Research Laboratory, 934 College Station Road, Athens, GA 30605, USA.
NAL Call Number: 47.8 B77
In spent hens from White Leghorn and White Rock layer flocks induced to moult by

withdrawal of food, lymphocyte numbers were lower in moulted birds than in nonmoulted controls. Antibody responses to sheep red blood cells or *Brucella abortus* antigen were largely unaffected. The delayed type hypersensitivity response to the skin sensitiser dinitrofluorobenzene (DNFB) was depressed during the period of food withdrawal but recovered when feeding resumed. It is concluded that induced moulting probably has a negative effect on the cellular component of the immune system of the moulted birds. Descriptors: cell mediated immunity, humoral immunity, immunity, molting, molt, immunosuppression

Holt PS; Buhr RJ; Cunningham DL (1993). **Comparison of molt induction by 14-day feed-removal versus the use of a low-energy, low density molt feed on the exacerbation of an intestinal *Salmonella enteritidis* infection on white leghorn hens.** *Poultry Science* 72 (Suppl.1): 90.

USDA/ARS, Southeast Poultry Research Laboratory, Athens, GA 30605

NAL Call Number: 47.8 Am33P

Holt PS; Buhr RJ; Cunningham DL; Porter RE Jr (1994). **Effect of induced molting via feed removal or low energy, low density feed on the severity of an intestinal infection by *Salmonella enteritidis* in white leghorn hens.** *Poultry Science* 73 (Suppl.1): 140.

USDA/ARS, Southeast Poultry Res. Lab., 934 College Station Road, Athens, GA 30605

NAL Call Number: 47.8 Am33P

Holt PS; Buhr RJ; Cunningham DL; Porter RE Jr (1994). **Effect of two different molting procedures on a *Salmonella enteritidis* infection.** *Poultry Science* 73(8): 1267-1275.

NAL Call Number: 47.8 Am33P

Previous studies have shown that inducing a molt using feed removal exacerbated an intestinal infection by *Salmonella enteritidis* (SE). The current study was conducted to determine whether inducing a molt using a molt diet would still cause a pause in egg laying but not exacerbate an intestinal SE infection. In Experiments 1 and 2, hens were either provided ad libitum access to layer feed (control), fed 45 g molt diet (molt-feed) daily, or deprived of feed for 14 d (molted), and were orally infected with 1×10^7 SE on Day 4 of molt. Egg lay ceased in hens subjected to both molt treatments. The percentage of hens shedding SE did not differ among treatment groups in Experiment 1, whereas in Experiment 2 the molted hens had significantly higher shed rates than the controls on Days 10, 17, and 24 postinfection and the molt-feed hens on Days 17 and 24 postinfection. Compared with both fed groups of hens, the molted hens shed significantly more SE in Experiment 1 on Day 10 postinfection, and in Experiment 2 the molted hens shed significantly more SE on all 4 sampling days. In Experiment 3, subgroups of hens within each treatment group received serial 10-fold dilutions of SE and intestinal shedding of the organism in each subgroup was determined 7 d later. The 50% infectious dose (ID₅₀) was calculated for each treatment group from these shedding results. The ID₅₀ was 2.7×10^3 SE, 5.2×10^2 SE, and 1.3 SE for control, molt-feed, and molted hens, respectively, indicating that feed removal substantially increased the susceptibility of hens to an SE infection and the molt diet

decreased this susceptibility. Little difference was observed in the pH of alimentary samples or of cecal contents from hens in each treatment group, indicating that increased severity of SE infection was not due to alterations of intestinal pH. Histologically, the molted hens exhibited more extensive inflammation of the intestinal tract at Day 4 postinfection compared with the unmolted group. Intestinal inflammation in the molt-feed hens was intermediate between the two. These results indicated that molt induction, using a molt diet, will not put hens at risk for the severe intestinal infection observed in birds subjected to feed removal. Descriptors: hens, salmonella enteritidis, molting, restricted feeding, fasting, unrestricted feeding, experimental infections, digesta, pH, digestive tract, inflammation

Holt PS; Macri NP; Porter RE Jr. (1995). **Microbiological analysis of the early *Salmonella enteritidis* infection in molted and unmolted hens.** *Avian Diseases* 39(1): 55-63.

USDA, ARS, Southeast Poultry Research Laboratory, Athens, GA.

NAL Call Number: 41.8 Av5

A study was conducted in which the early kinetics (4 hr to 96 hr) of an infection by *Salmonella enteritidis* in older white leghorn hens was examined, and a molt was induced through withholding feed to determine its effect on the progression of this infection. Molted and unmolted hens were orally infected with $5-10 \times 10^6$ *S. enteritidis* on day 4 of the feed removal. At 4, 24, 48, 72, and 96 hr postinfection, liver, spleen, ileum, colon, cecum, and feces were removed from six hens per group and sampled for the presence of the challenge organism. By 24 hr postinfection, *S. enteritidis* was most prevalent in the cecum and feces of unmolted hens, and this prevalence continued throughout the experimental period. In molted hens, however, *S. enteritidis* could be determined in a high percentage (90-100%) of colon, cecum, and feces samples at 24 to 96 hr postinfection and in 67% or more of ileum samples at 48 to 96 hr postinfection, indicating a much wider distribution of the *S. enteritidis* along the intestinal tract than in unmolted hens. The numbers of *S. enteritidis* recovered from these alimentary samples were also significantly higher in molted than unmolted hens. *S. enteritidis* could not be detected in livers or spleens of either treatment group at 4 or 24 hr postinfection. At 48, 72, and 96 hr postinfection, 50% or more of the livers and spleens in both the molted and unmolted hens were positive for the challenge organism, but significantly more *S. enteritidis* was recovered from the organs of the molted hens at these three sampling times. These results indicate that induced molting has a profound effect on both intestinal and extraintestinal infection by *S. enteritidis*, and these effects occur within 24 hr postinfection in the intestine and within 48 hr postinfection in the livers and spleens.

Descriptors: hens, salmonella enteritidis, molt, fasting, bacterial diseases, disease course, liver, spleen, ileum, colon, cecum, feces

Holt PS; Mitchell BW; Gast RK (1998). **Airborne horizontal transmission of *Salmonella enteritidis* in molted laying chickens.** *Avian Diseases* 42(1): 45-52.

USDA, ARS, Southeast Poultry Research Laboratory, Athens, GA.

NAL Call Number: 41.8 Av5

Salmonella enteritidis is currently thought to be transmitted principally through contact with infected individuals and ingestion of fecally contaminated materials. The present study was

undertaken to determine if *S. enteritidis* could be spread in chickens by the airborne route and if induced molting could affect this mode of transmission. To test for airborne transmission, hens were placed in two rows of cages, the rows separated from each other by 1 m. One row of hens was challenged with *S. enteritidis*, whereas the other row remained unchallenged but exposed to the room air. Ventilation delivered within the room provided an even air distribution within the area and minimized directional air flow toward any set of cages. In Expt. 1, 4 of 12 and 9 of 12 exposed molted hens became infected with *S. enteritidis* after 3 and 8 days of exposure, respectively, compared with 1 of 12 and 0 of 12 unmolted hens sampled on the same days. Similar *S. enteritidis* levels were detected circulating in the air in the two rooms housing the hens. Expts. 2 and 3 examined airborne transmission in molted hens only. In Expt. 2, 2 of 12 exposed hens became infected with *S. enteritidis* at 3 days postchallenge, and this increased to 12 of 12 1 wk later. In Expt. 3, exposed hens were again housed in cages 1 m from challenged hens but were placed in every other cage to prevent transmission through contact with hens in adjacent cages. At day 3 post challenge, 0 of 12 exposed hens were culture positive for *S. enteritidis*, and this increased to only 3 of 10 positive hens at day 10. Large numbers of *S. enteritidis* shed by the molted challenged hens were recovered from the floors beneath the cages. These results indicate that, contrary to the generally held beliefs regarding organism spread, airborne transmission *S. enteritidis* can occur and induced molting can provide the impetus for this event. As was observed previously, rapid dissemination of the organism to other members of the flock resulted through bird-to-bird contact.

Descriptors: hens, salmonella enteritidis, disease transmission, airborne infection, molting, ventilation, experimental infection, epidemiology

Holt PS; Porter RE Jr. (1993). **Effect of induced molting on the recurrence of a previous *Salmonella enteritidis* infection.** *Poultry Science* 72(11): 2069-2078.

NAL Call Number: 47.8 Am33P

Previous work in the authors' laboratory had shown that hens infected with *Salmonella enteritidis* (SE) during the feed removal phase of an induced molt shed significantly more SE and more readily transmitted SE to uninfected hens in adjacent cages when compared with unmolted hens. A study was conducted to examine the effect of induced molting on the recurrence and horizontal transmission of a previous SE infection. Hens aged 59 and 69 wk in Trials 1 and 2, respectively, were infected with SE and then molted 21 days later. In Trial 1, more molted hens were SE-culture-positive on Days 38 (P less than or equal to .005) and 45 (P less than or equal to .005) postinfection, and these hens shed more SE on these days (P less than or equal to .05 and P less than or equal to .005, respectively) than unmolted hens. Horizontal transmission of SE to previously uninfected but contact exposed hens in adjacent cages was also higher in the molted group than the unmolted group on Days 38 (P less than or equal to .05) and 45 (P less than or equal to .001). Molted, contact-exposed hens also shed significantly more SE than unmolted hens. In Trial 2, the molted infected hens shed progressively more SE than the unmolted hens but the differences were not significant. However, more molted contact-exposed hens became SE-positive at Day 31 (P less than or equal to .05) and 38 (P less than or equal to .005) and also shed more SE on these days (P

less than or equal to .05 and P less than or equal to .01, respectively) than the unmolted hens. Serum and intestinal antibody titers to SE were also examined in Trial 2. Molting appeared to exert no effect on the serum SE titers, but antibody titers in the alimentary tract were lower in the molted hens than the unmolted hens on Days 45 (P less than or equal to .005) and 52 (P less than or equal to .05). In Trial 1, three of eight molted directly infected hens and two of eight molted contact-exposed hens produced an SE-contaminated egg, but none of the unmolted hens produced any SE-contaminated eggs. In Trial 2, no SE-contaminated eggs were produced.

Descriptors: hens, salmonella enteritidis, molting, relapse, susceptibility, disease transmission, stress

Holt PS; Porter RE Jr. (1992). **Effect of induced molting on the course of infection and transmission of *Salmonella enteritidis* in White Leghorn hens of different ages.** *Poultry Science* 71(11): 1842-1848.

USDA, ARS, Southeast Poultry Research Laboratory, Athens, GA

NAL Call Number: 47.8 AM33P

Previous work in the authors' laboratory had shown that inducing molt using a 2-wk feed removal protocol in 58- to 84-wk-old White Leghorn hens increased the severity of intestinal infection by *Salmonella enteritidis* (SE). As susceptibility to infection can be influenced by age, a study was conducted to compare the effect of the feed removal on infection by SE in 20-, 40-, and 74-wk-old hens. Birds were orally infected with 5 to 10 X 10⁶ SE on Day 4 of fast and were sampled for SE shedding 3, 10, 17, and 24 days later. Significantly higher numbers of SE were shed in fasted birds on Day 3 (20 and 40 wk of age), Day 10 (40 and 74 wk of age), and Day 17 (74 wk of age). Transmission of SE to uninfected, contact-exposed birds was observed in all three trials for both the fed and fasted groups. However, significantly more fasted contact-exposed birds became positive for SE on Day 3 (20-wk-old), Day 10 (74-wk-old), and Day 17 (74-wk-old). Significantly more SE was also shed in these fasted contact-exposed birds on Day 3 (20-wk-old), Day 10 (all age groups), and Day 17 (74-wk-old). The current results indicate that the fasting conditions used to induce a molt in hens increase the shedding of SE in direct-infected and contact-exposed hens and this effect does not appear to be affected by age.

Descriptors: hens, age differences, molting, fasting, salmonella enteritidis, susceptibility, aging, disease transmission, disease course

Holt PS; Porter RE Jr. (1993). **Effect of induced molting on the recurrence of a previous *Salmonella enteritidis* infection.** *Poultry Science* 72(11): 2069-2078.

NAL Call Number: 47.8 Am33P

Previous work in the authors' laboratory had shown that hens infected with *Salmonella enteritidis* (SE) during the feed removal phase of an induced molt shed significantly more SE and more readily transmitted SE to uninfected hens in adjacent cages when compared with unmolted hens. A study was conducted to examine the effect of induced molting on the recurrence and horizontal transmission of a previous SE infection. Hens aged 59 and 69 wk in Trials 1 and 2, respectively, were infected with SE and then molted 21 days later. In Trial

1, more molted hens were SE-culture-positive on Days 38 (P less than or equal to .005) and 45 (P less than or equal to .005) postinfection, and these hens shed more SE on these days (P less than or equal to .05 and P less than or equal to .005, respectively) than unmolted hens. Horizontal transmission of SE to previously uninfected but contact exposed hens in adjacent cages was also higher in the molted group than the unmolted group on Days 38 (P less than or equal to .05) and 45 (P less than or equal to .001). Molted, contact-exposed hens also shed significantly more SE than unmolted hens. In Trial 2, the molted infected hens shed progressively more SE than the unmolted hens but the differences were not significant. However, more molted contact-exposed hens became SE-positive at Day 31 (P less than or equal to .05) and 38 (P less than or equal to .005) and also shed more SE on these days (P less than or equal to .05 and P less than or equal to .01, respectively) than the unmolted hens. Serum and intestinal antibody titers to SE were also examined in Trial 2. Molting appeared to exert no effect on the serum SE titers, but antibody titers in the alimentary tract were lower in the molted hens than the unmolted hens on Days 45 (P less than or equal to .005) and 52 (P less than or equal to .05). In Trial 1, three of eight molted directly infected hens and two of eight molted contact-exposed hens produced an SE-contaminated egg, but none of the unmolted hens produced any SE-contaminated eggs. In Trial 2, no SE-contaminated eggs were produced.

Descriptors: hens, salmonella enteritidis, molting, relapse, susceptibility, disease transmission, stress

Holt PS; Porter RE Jr. (1992). **Effect of induced molting on severity of *Salmonella enteritidis* infection in different aged hens.** *Poultry Science* 71(Suppl.1): 156.

USDA/ARS, Southeast Poultry Research Laboratory, Athens, GA. 30605.

NAL Call Number: 47.8 Am33P

Descriptors: bacteria, microorganism, bird, starvation, intestinal disease, poultry industry

Holt PS; Porter RE Jr. (1992). **Induced molting increases severity and recrudescence of *Salmonella enteritidis* intestinal infections in laying hens.** *Proceedings 19th World's Poultry Congress Amsterdam 19-24 September 1992*, Volume 1: 346-349.

NAL Call Number: SF481.2 W6 1992

Descriptors: bacterial diseases, poultry, food deprivation, egg production, moulting, predisposition, stress, poultry diseases, *Salmonella enteritidis*

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Holt PS; Porter RE Jr. (1992). **Microbiological and histopathological effects of an induced-molt fasting procedure on a *Salmonella enteritidis* infection in chickens.** *Avian Diseases* 36(3): 610-618.

USDA, ARS, Southeast Poultry Research Laboratory, Athens, GA

NAL Call Number: 41.8 AV5

A study was undertaken to determine if a 2-week feed-removal protocol, as is used by industry to induce a molt in aging hens, could affect the course of a *Salmonella enteritidis* infection. White leghorn hens aged 69-84 weeks were deprived of feed to induce a molt, and

on day 4 of the fast, the birds were orally infected with 5×10^6 *S. enteritidis*. *S. enteritidis* organisms were enumerated in the spleen on day 6 and from the alimentary tract on days 7, 14, 21, 28, and 35. Little difference was detected in numbers of *S. enteritidis* from spleens of molted and unmolted hens. Significantly more molted hens shed detectable intestinal *S. enteritidis* than unmolted hens on day 14 (one of two trials) and day 21 (one of two trials). Intestinal levels of *S. enteritidis* were increased 100- to 1000-fold in the molted birds on day 7 (one of two trials) and day 14 (two of two trials), and many of the hens exhibited bloody alimentary secretions. Histological examination of the intestinal tract of *S. enteritidis*-infected molted hens showed increased inflammation in the epithelium and lamina propria of colons and ceca, compared with unmolted infected hens.

Descriptors: hens, salmonella enteritidis, molting, food deprivation, experimental infection, histopathology, disease course, immune response

Holt PS; Porter RE (1991). **Effects of induced molting on immunocompetence and susceptibility to *Salmonella enteritidis* (SE) infection in laying hens.** *Poultry Science* 70(Suppl. 1): 53.

NAL Call Number: 47.8 Am33P

Descriptors: Salmonellosis, Immune response, disease resistance

Horuto P (1998). **The SE countermeasure in hen. 1. Concentrating countermeasure in forced molting and day-old chicken. Effect of aerial negative ionization.** *Niwatori no Kenkyu* 73(12): 23-26.

NAL Call Number: 47.8 N64

Descriptors: laying hen, animal hygiene, Salmonella enteritidis, bird disease, rearing management, chick, indoor air, anion, forced ventilation, antibiotics, forced molting

Humphrey TJ; Baskerville A; Whitehead A; Rowe B; Henley A (1993). **Influence of feeding patterns on the artificial infection of laying hens with *Salmonella enteritidis* phage type 4.** *The Veterinary record : Journal of the British Veterinary Association* 132(16): 407-409.

NAL Call Number: 41.8 V641

Descriptors: hens, salmonella enteritidis, food deprivation

Ito T (1999). **HACCP as prevention measures for *Salmonella* food poison in the U.S. and food poisoning tendency by foodservice facilities in Japan and countermeasures.** *Shokuhin Eisei Joho* 10(2): 1-8.

Tokyo Kenbikyoin

Descriptors: HACCP, USA, food poisoning, chicken egg, chicken house, Salmonella, rat, food service, cooking place, microorganism contamination, heating, heat sterilization, education and training, consumer, rearing management, forced molting

Jones DR; Anderson KE; Curtis PA; Jones FT (2002). **Microbial contamination in inoculated shell eggs: I. Effects of layer strain and hen age.** *Poultry Science* 81(5): 715-720.

Department of Poultry Science, North Carolina State University, Raleigh, North Carolina

NAL Call Number: 47.8 Am33P

Three Ottawa control strains and a current commercial laying stock were reared and housed under identical environmental and management conditions. Eggs were collected from each strain when hens were 32, 45, 58, 71, and 84 wk of age. The eggs were inoculated with *Salmonella enteritidis* (SE), *Pseudomonas fluorescens* (PF), or a combination of the two. After storage at 26 C, bacterial counts were obtained from the exterior shell surfaces (rinse), air cell, egg contents, and shell structure. SE and PF survived at different rates on the shell surface with as much as a 1 log difference during a given collection period. Egg content counts tended to be higher than eggshell counts in PF, whereas the opposite was true for SE. These data suggest that PF is a primary invader of eggs that is more capable of contaminating egg contents through the shell membranes than SE. The PF and SE data suggest that bacterial contamination of air cells, shells, and egg contents is more easily achieved in eggs from older hens than from younger hens. There were also differences between the strains. Control Strain 10 consistently maintained a lower level of contamination for both organisms in each sampling location. The overall results of this study suggest that genetic selection has altered the ability of eggs to resist microbial contamination and that screening for microbial integrity should be considered in the selection process among the laying egg breeders.

Kato H(1999). **For right knowledge and correspondence of *Salmonella enteritidis*(SE). 144.**

Concepts of HACCP in raising of layer. 9. *Keiranniku Joho (Poultry Magazine)* 29(11): 42-46.

Descriptors: laying hen, chicken egg, HACCP, *Salmonella enteritidis*, rearing management, clostridium infection, coccidiosis, bird disease, *Salmonella enteritidis*, forced molting

Keiranniku Joho (1998). **State of Maryland Department of Agriculture.** *Keiranniku Joho (Poultry Magazine)* 28(9): 48-52.

Descriptors: Maryland, *Salmonella enteritidis*, chicken egg, food contamination, laying hen, rearing management, slaughter and dressing, slaughter house, forced molting

Kogut MH; Genovese KJ; Stanker LH (1999). **Effect of induced molting on heterophil function in White Leghorn hens.** *Avian Diseases* 43(3): 538-548.

USDA, ARS, Food Animal Protection Research Laboratory, College Station, TX.

NAL Call Number: 41.8 Av5

This study was undertaken to determine the effects of induced molt on basal functional activities of heterophils from aging hens. For this purpose, heterophils from both molted and unmolted hens were examined by in vitro bioassays for functional responsiveness and efficiency. We evaluated the ability of the heterophils to migrate to chemotactic stimuli, phagocytize opsonized and nonopsonized *Salmonella enteritidis* (SE), and generate an oxidative burst in response to inflammatory agonists. A significant ($P < 0.001$) heterophilia was found in the molted hens within 2 days after feed withdrawal and remained throughout the length of the experimental feed withdrawal period. No significant differences were found in the random migration of heterophils from either group. The chemotactic movement of heterophils from molted hens was not affected until 8 days after feed withdrawal when compared with heterophil chemotaxis from unmolted hens. A significant decrease in

chemotaxis by the heterophils from molted hens was observed days 8-12 after feed withdrawal ($P < 0.05$). Significantly ($P < 0.05$) fewer heterophils from molted hens were able to phagocytize opsonized (59% vs. 38%) and nonopsonized (26% vs. 15%) SE within 2 days after feed withdrawal. Likewise, significantly ($P < 0.05$) fewer bacteria were phagocytized per heterophil from the molted hens when compared with the number of bacteria per heterophil from the unmolted hens. The oxidative burst of heterophils stimulated by either opsonized zymosan A or phorbol myristate acetate of heterophils from molted hens was significantly ($P < 0.05$) reduced when compared with that generated by heterophils from the unmolted hens. These results indicate that feed withdrawal to induce molt alters the number and function of peripheral blood heterophils. This decreased efficiency, of heterophil functional activity appears to play a role in the increased susceptibility of molting hens to SE infections.

Descriptors: hens, molting, phagocytes, phagocytosis, salmonella enteritidis, chemotaxis, defense mechanisms

Latshaw JD (1991). **Nutrition--mechanisms of immunosuppression.** *Veterinary Immunology and Immunopathology* 30(1): 111-20.

Department of Poultry Science, Columbus, OH 43210

NAL Call Number: SF757.2 V38

Nutritionists must formulate diets that supply adequate amounts of nutrients from five major groups. These are carbohydrate, protein (amino acids), fat, minerals and vitamins. Carbohydrate is usually a cheaper source of energy than fat, but fat is often used to increase the caloric concentration of the diet. Variations in energy intake which may effect immunocompetence usually result from management practices rather than diet formulation. Feed restriction for broiler breeders and withholding feed in forced molting practices may affect immunocompetence. Feed restriction causes higher plasma corticosterone levels, which are known to decrease the immune response, possibly through effects on cytokines. Excessive feed, through forced feeding, may also have short-term effects on indicators of humoral immunity. Protein and amino acid nutrition have been studied in relation to immunocompetence. The level of dietary amino acid needed to maximize growth and feed efficiency will also generally maximize measures of immunocompetence. The level of amino acids needed for maximum growth is lower in chicks which have been immunologically stressed than in chicks which have not. An immune response changes metabolism so that less growth occurs, thereby decreasing the need for amino acids. Dietary levels of minerals can affect immunocompetence. While deficient levels of sodium and chloride decrease humoral immunity, levels of these nutrients which supported maximum growth also supported maximal humoral immunity. Low dietary zinc levels did not affect indicators of immunocompetence in the chick. The effect of fat soluble vitamin levels on the immune system has been studied. Vitamin A is needed to maintain epithelial tissue and prevent infection. Cellular immune response is decreased when the chick is deficient in this nutrient. Several indicators of immune responsiveness are depressed when chicks are vitamin E and/or selenium deficient. Since these nutrients serve as antioxidants, cellular integrity may be affected by a deficiency. Cellular integrity is very important for receiving, and responding to

the messages needed to coordinate an immune response. High levels of vitamin E (greater than 10 times the required level) have been found to be immunostimulatory.

Descriptors: Animal Nutrition, Chickens--immunology--IM, Immune Tolerance , Avitaminosis--immunology--IM, Poultry Diseases--immunology--IM, Virus Diseases--immunology--IM, Virus Diseases--veterinary--VE

Le Floch N (1992). **[Effect of starvation and cooling on chick sensibility for *Salmonella* infection]** **Effet de la privation alimentaire et hydrique et du refroidissement sur la sensibilité du poussin à l'infection salmonellique.** *Ecole Nationale Veterinaire de Nantes (France) Thesis Degree: Doctorat (These)* , 7 Feb 1992 , 108 p.

Availability: INRA, Centre de Jouy, Unite Centrale de Documentation, Domaine de Vilvert, 78350 Jouy en Josas (Fr)

Descriptors: chicks, salmonella typhimurium, pathogenicity, stress, water deprivation, malnutrition, biological contamination, in vivo experimentation , bacteria, biological properties, birds, chickens, contamination, domestic animals, domesticated birds, enterobacteriaceae, experiments, galliformes, livestock, microbial properties, poultry, salmonella, useful animals, young animals

Leitner G; Heller ED (1992). **Colonization of *Escherichia coli* in young turkeys and chickens.** *Avian Diseases* 36(2): 211-220.

Department of Animal Science, Hebrew University of Jerusalem, Faculty of Agriculture, Rehovot, Israel

NAL Call Number: 41.8 Av5

In order to investigate the possibility of pathogenic *Escherichia coli* penetrating the bloodstream via the intestinal mucosa in normal and stressed turkeys and chickens, birds were inoculated orally with the bacteria or exposed environmentally to it. Immediately after hatch, intestines contained a substantial number of coliform bacteria that increased with time. In orally infected turkeys, the pathogenic bacteria (nalidixic-acid-resistant O78) replaced 10%-50% of the native coliform flora but could not be isolated from the trachea or blood. Environmentally exposed groups exhibited pathogenic bacteria in intestines but not in blood. Stressing of exposed turkeys resulted in isolation of the pathogenic bacteria from blood and even spleen. In orally infected broiler chickens, stress resulted in bacteremia and mortality. Chickens that were exposed to pathogenic bacteria at a young age and showed no mortality or morbidity demonstrated no detrimental effects due to challenge with the same pathogenic bacteria later in life. Stress seems to cause penetration of the pathogenic bacteria into the bloodstream, which in turn can cause severe disease and mortality.

Descriptors: *Chickens; **Escherichia coli*--physiology--PH; **Escherichia coli* Infections --veterinary--VE; *Poultry Diseases--microbiology--MI; *Turkeys ; Bacteremia--etiology--ET; Bacteremia--microbiology--MI; Bacteremia --veterinary--VE; Carrier State--microbiology--MI; Carrier State --veterinary--VE; *Escherichia coli*--isolation and purification--IP; *Escherichia coli*--pathogenicity--PY; *Escherichia coli* Infections--etiology --ET; *Escherichia coli* Infections--microbiology--MI; Food Deprivation; Heat--adverse effects--AE; Intestines--microbiology--MI; Poultry Diseases --etiology--ET;

Spleen--microbiology--MI; Stress--complications--CO; Stress--veterinary--VE; Water Deprivation

Leitner G; Waiman R; Heller ED (2001). **The effect of apramycin on colonization of pathogenic *Escherichia coli* in the intestinal tract of chicks.** *Veterinary Quarterly* (Netherlands) 23(2): 62-66.

Kimron Veterinary Institute, Bet Dagan, Israel.

NAL Call Number: SF601 V46

The purpose of the present study was to examine the effect of apramycin sulphate on the colonization of pathogenic *E. coli* in the intestines of chicks. Apramycin treatment (0.5g/l in the drinking water) of 3-to 5-week-old Leghorn chicks for 24 or 48 hours resulted in a reduction, to an undetectable level, in the number of coliforms in the digestive tract for at least the first 24 h. Per os inoculation of *E. coli* (O2:K1) after 24 to 48 h of treatment resulted in a significant decrease in colony forming units (cfu) in the digestive tract of the treated chicks. Food deprivation from the time of inoculation did not significantly change the results. However, food and water deprivation caused bacteraemia in a number of the control chicks but not in the treated chicks. Comparison of the level of protection between Leghorn and broiler (Anak strain) chicks revealed that there was a significantly higher ($P<0.05$) level of bacteraemia in the broiler than in the Leghorn chicks. Chicks treated with 0.25 g/l or 0.125 g/l apramycin for 24 or 48 h before *E. coli* inoculation showed significantly lower cfu in the colon and caecum than untreated control chicks, but significantly higher cfu were found in the colon than in chicks treated with 0.5 g/l apramycin. Although in vitro preincubation of apramycin with ileum cells did not decrease the percentage of cells to which the bacteria adhered, the number of bacteria adhered per cell decreased significantly. Taken together, our in vitro and in vivo results show that apramycin is effective against *E. coli* by preventing colonization of the gut by the bacteria, which could lead to a reduction of colibacillosis in poultry.

Descriptors: *Antibiotics, Aminoglycoside--pharmacology--PD; *Chickens; *Escherichia coli--drug effects--DE; *Escherichia coli Infections--veterinary--VE; *Nebramycin--analogs and derivatives--AA; *Nebramycin--pharmacology--PD; *Poultry Diseases--prevention and control--PC ; Bacteremia--etiology--ET; Bacteremia--veterinary--VE; Bacterial Adhesion --drug effects--DE; Cells, Cultured; Colony Count, Microbial--veterinary --VE; Escherichia coli--pathogenicity--PY; Escherichia coli Infections --drug therapy--DT; Escherichia coli Infections--prevention and control --PC; Food Deprivation; Intestines--microbiology--MI; Poultry Diseases --drug therapy--DT; 10Water Deprivation

Lloyd AB (1978). **Salmonellosis and stress.** *Proceedings Second Australasian Poultry and Stock Feed Convention*, 12-17 March, p.253-254.

NAL Call Number: SF95 A8 1978

Descriptors: poultry, bacterial diseases, hygiene, cold zones, social behaviour, food deprivation, carrier state, predisposition, stress, poultry diseases, salmonellosis

Macri NP; Porter RE; Holt PS (1997). **The effects of induced molting on the severity of acute intestinal inflammation caused by *Salmonella enteritidis*.** *Avian Diseases* 41(1): 117-124. Purdue University, Animal Disease Diagnostic Laboratory, West Lafayette, IN.

NAL Call Number: 41.8 Av5

This study describes and compares early inflammation caused by *Salmonella enteritidis* in molted and nonmolted hens. Adult white leghorn chickens were orally infected with *Salmonella enteritidis* 4 days after feed removal. At 2, 4, 8, 10, 24, 48, 72, and 96 hr after infection, the hens were euthanatized, and the duodenum, jejunum, ileum, cecum, and colon were evaluated by light microscopy. Two trials were conducted, and in both trials inflammation occurred more frequently and was significantly greater in the cecum and colon of molted-infected hens compared with nonmolted-infected hens beginning at 8 hr after infection. In one trial, inflammation was more severe in the ileum of molted-infected hens compared with nonmolted-infected hens. Results indicated that molting by feed deprivation shortened the time of onset and increased the severity of acute intestinal inflammation caused by *Salmonella enteritidis*.

Descriptors: chickens, salmonella enteritidis, molting, restricted feeding, disease course, inflammation, intestines, experimental infections

Maxwell MH; Robertson GW; Anderson IA; Dick LA; Lynch M (1991). **Haematology and histopathology of seven-week-old broilers after early food restriction.** *Research in Veterinary Science* 50(3): 290-297.

Agricultural and Food Research Council Institute of Animal Physiology and Genetics Research, Edinburgh Research Station, Roslin, Midlothian EH25 9PS (United Kingdom)

NAL Call Number: 41.8 R312

Descriptors: chicks, broiler chickens, pathogenesis, deficiency diseases, blood , pathology, nutritional disorders, birds, chickens, disorders, domestic animals, domesticated birds, functional disorders, galliformes, livestock, meat animals, poultry, useful animals, young animals

McElroy AP; Manning JG; Jaeger LA; Taub M; Williams JD; Hargis BM (1994). **Effect of prolonged administration of dietary capsaicin on broiler growth and *Salmonella enteritidis* susceptibility.** *Avian Diseases* 38(2): 329-333.

NAL Call Number: 41.8 Av5

The effect of continuous (42 days) dietary administration of 5 or 20 ppm capsaicin to broiler chickens on *Salmonella enteritidis* susceptibility, body weight, and feed efficiency was investigated. Chickens were weighed at 1, 21, and 42 days of age. No significant differences in body weight or feed efficiency were observed. Chickens were challenged with 1×10^8 colony-forming units of *S. enteritidis* at 21, 28, or 42 days of age. The *S. enteritidis*-positive culture rate for cecal tonsils was significantly lower ($P < 0.05$) in the treatment groups receiving 5 ppm or 20 ppm dietary capsaicin than in the untreated control group at all challenge times. Dietary capsaicin (5 and 20 ppm) resulted in protection against *S. enteritidis* organ invasion at 28 days in one experiment and at both 21 and 42 days in the other. These results indicate that continual dietary capsaicin administration increases resistance to *S.*

enteritidis colonization and organ invasion throughout the normal growth period without detrimental effects on growth in broiler chickens,

Descriptors: broilers, capsaicin, chemoprophylaxis, Salmonella enteritidis, susceptibility, disease prevention, body weight, feed conversion efficiency, growth rate, colonization

Mityushnikov VM; Kozharinova TA (1976). **Effect of forced moulting on the resistance of hens to disease.** *Veterinariya, Moscow* (No.8): 39-41.

Descriptors: disease resistance, moulting, animal husbandry, poultry

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Mohammed HO; Carpenter TE; Yamamoto R; Mcmartin DA (1986). **Prevalence of *Mycoplasma gallisepticum* and *Mycoplasma synoviae* in commercial layers in Southern and Central California USA.** *Avian Disease* 30(3): 519-526.

Department of Epidemiology and Preventive Medicine, School of Veterinary Medicine, University of California, Davis, California 95616.

The prevalence of *Mycoplasma gallisepticum* (MG) and *M. synoviae* (MS) in commercial pullet and layer flocks in Southern and Central California was estimated by testing serum and egg-yolk samples from 360 sample flocks in Southern California and 41 sample flocks in Central California. Data relating to potential risk factors associated with MG and MS infections were collected. The estimated true prevalence rate of MG was 73% in Southern California and 3% in Central California. The estimated true prevalence rate of MS was 91% in Southern California and 32% in Central California. Compared with uninfected flocks, MG-infected flocks in Southern California were significantly older and were medicated less ($P < 0.05$). More managements were under a multiple-age system, more flocks had molted, more were vaccinated with F-strain, and more had concurrent infection with MS ($P < 0.05$). Only one sample flock in Central California was MG-infected; none were vaccinated with F-strain. In Southern California, MS-infected flocks were older than uninfected flocks, more had molted, more were medicated, and more had concurrent infection with MG ($P < 0.05$). In Central California, MS-infected flocks did not differ significantly from uninfected flocks in any factor examined; the lack of statistical significance may be due to small sample size.

Descriptors: risk factors, age, medication, multiple-age management, molt history, F-strain, vaccination, concurrent infection

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Mondini S (1980). **Cannibalism due to earthquake in laying hens after forced moult.**

[Cannibalismo (da terremoto?) in ovaiole da consumo in muta forzata]. *Clinica Veterinaria* 103(7): 456-458.

Ist. Allevamenti Zootecnici, Università, Bologna, Italy

NAL Call Number: 41.8 C61

When a previously successful method was used to induce moult in 7107 hens, 224 (3%) died in the following 10 days as a result of cannibalism. This had not occurred in the 400 000 already treated, the only difference this time being an earth tremor of intensity IV on the Mercalli scale on the day after moult induction.

Descriptors: etiology, disasters, moulting, cannibalism
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Nakamura M (1999). **Transmission of *Salmonella enterica* serovar *Enteritidis* and effect of stress on shedding in laying hens.** In *Salmonella enterica* serovar *Enteritidis* in humans and animals: epidemiology, pathogenesis, and control, Saeed AM; Gast RK; Potter ME; Wall PG (Eds.), Iowa State University Press: Ames, Iowa, p.377-389.

NAL Call Number: RA644 S15 S23 1999

Descriptors: disease transmission, stress, restraint of animals, vertical transmission, egg shell, contamination, experimental infections, water deprivation, food deprivation, social behaviour, heat, cold zones, poultry

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Nakamura M (1999). **For right knowledge and correspondence of *Salmonella enteritidis*(SE). 146. *Salmonella* pollution control strategy of egg 1. For control of *Salmonella* food poison. Effect of stress on *Salmonella* infection of chicken.** *Keiranniku Joho (Poultry Magazine)* 29(13): 40-46.

Kitasato Univ., Sch. of Vet. Med. and Anim. Sci.

Descriptors: Gallus, stress(physiology), *Salmonella*, bird disease, bacterium count, cecum, egg-laying, air duct(respiration), vitamin, rearing management, chicken egg, germ excluding, forced molting

Nakamura M (1999). ***Salmonella* (SE) countermeasure in layer hen.** (Japan chicken raising society S). *Yokei Seisan Taio Shisutemu Kento Jigyo*, p. 2-6.

Kitasato Univ., Sch. of Vet. Med. and Anim. Sci.

Descriptors: *Salmonella enteritidis*, Gallus, bird disease, salmonellosis, pathogenicity, USA, Japan, bacteria test, rearing management, stress(physiology), United Kingdom, Netherlands, prevention, *Salmonella enteritidis*, pullorum disease, forced molting

Nakamura M (1995). **Effect of forced molting on the salmonellosis infection.** *Yokei Gijitsu to keiei* 5: 9-13.

Ministry of Agriculture, Forestry, and Fisheries, National Veterinary Assay Laboratory

Descriptors: rearing management, salmonellosis, bird disease, *Salmonella enteritidis*, Gallus, prevention of animal epidemic, heat stress, fasting

Nakamura M; Nagamine N; Takahashi T; Norimatsu M; Suzuki S; Sato S (1995). **Intratracheal infection of chickens with *Salmonella enteritidis* and the effect of feed and water deprivation.** *Avian Diseases* 39(4): 853-858.

Kitasato University, Towada, Aomori, Japan.

NAL Call Number: 41.8 Av5

The tissue distribution of *Salmonella enteritidis* in intratracheally inoculated chickens and the effect of deprivation of food and water on tissue distributions of the bacteria have been investigated. Seven-week-old specific-pathogen-free chickens were inoculated intratracheally

with 10(2), 10(5), or 10(8) cells and orally with 10(5) cells. The intratracheally inoculated organisms entered the blood stream immediately after inoculation and produced generalized infection. Infection by the intratracheal route resulted in colonization of *S. enteritidis* in the cecum that was similar to infection by the oral route. The tissue distribution of *S. enteritidis* was markedly affected when chickens were deprived of food and water for a short time, demonstrating an increased susceptibility of chickens to *S. enteritidis* infection. This suggests that stresses such as food and water deprivation are one of the causes of the rapid dissemination of *S. enteritidis* among chickens in poultry houses.

Descriptors: chickens, salmonella enteritidis, experimental infection, trachea, application methods, stress, food deprivation, water deprivation, susceptibility, animal tissues, oral administration

Nakamura M; Nagamine N; Takahashi T; Suzuki S; Kijima M; Tamura Y; Sato S (1994).

Horizontal transmission of *Salmonella enteritidis* and effect of stress on shedding in laying hens. *Avian Diseases* 38(2): 282-288.

NAL Call Number: 41.8 Av5

Horizontal transmission of *Salmonella enteritidis* in laying hens and the short-term effect of stress on shedding were examined in 32 seven-month-old laying hens. Half were inoculated with 10(5) colony-forming units of *S. enteritidis* phage type 4, and the remaining half were left uninoculated to study horizontal transmission. Isolation of *S. enteritidis* from cecal droppings of all hens was attempted every morning. Uninoculated hens rapidly became infected through contaminated drinking water. Introduction of young chickens to the same rearing room and withdrawal of water and feed for 2 days coincided with a rapid increase in the shedding rate of *S. enteritidis* for a short period of time. The results showed that a short-term increase in the shedding rate of *S. enteritidis* is associated with short-term exposure to environmental stress.

Descriptors: hens, salmonella enteritidis, disease transmission, stress, dexamethasone, immunosuppression, egg production

Nakamura M; Saeed AM (ed.); Gast RK (ed.); Potter ME (ed.); Wall PG (1999). **Transmission of *Salmonella enterica* serovar *Enteritidis* and effect of stress on shedding in laying hens.** In *Salmonella enterica* serovar *Enteritidis* in humans and animals: epidemiology, pathogenesis, and control, p. 377-389.

NAL Call Number: RA644 S15 S23 1999

Descriptors: disease transmission, stress, restraint of animals, vertical transmission, egg shell, contamination, experimental infections, water deprivation, food deprivation, social behaviour, heat, cold zones

Nihon'yokeikyo (1998). **Guideline of *Salmonella* countermeasure in egg-laying farm.** *Keiranniku Joho (Poultry Magazine)* 28(19): 42-46.

Descriptors: laying hen, salmonellosis, bird disease, guiding principle, animal hygiene, microorganism test, rearing management, sterilization(disinfection), cleaning(sweeping), forced molting

Niwatori no Kenkyu (1998). **Effect of feed additives. 3. Production of much high quality of chicken meat and eggs, by improving productivity. Supply of the safety food by using oligosaccharides.** *Niwatori no Kenkyu* 73(10): 41-44.

NAL Call Number: 47.8 N64

Descriptors: commentary, Gallus, feed additive, oligosaccharide, diarrhea, umami, egg-laying, Salmonella, offensive odor, reducing sugar, rearing management, forced molting

Oyarzabal OA; Conner DE (1996). **Application of direct-fed microbial bacteria and fructooligosaccharides for *Salmonella* control in broilers during feed withdrawal.** *Poultry Science* 75(2): 186-190.

Department of Poultry Science, Auburn University, Alabama 36849-5416, USA.

NAL Call Number: 47.8 Am33P

Providing direct-fed-microbial (DFM) bacteria and fructooligosaccharides (FOS) for the control of potential escalation of *Salmonella* colonization during simulated feed withdrawal and confinement was assessed. Eight hundred and eighty broilers (16 pens; 55 chicks per pen) were reared to 6 wk of age. Chicks were sprayed with a solution containing 10(6) nalidixic-acid resistant *Salmonella* typhimuriumNR cells per milliliter on the 2nd d after hatching. Because this first challenge did not yield a high infection rate, chickens were rechallenged per Os at Day 18 by providing water containing 10(7) cells of *S. typhimuriumNR* per milliliter. At 3 and 5 wk of age, 10 birds per pen were euthanatized and cecal *Salmonella* were quantified (log colony-forming units per gram). Feed was removed from all pens at 6 wk, and pens were randomly assigned to be either the treatment group or the control group. The treatment groups were provided a DFM (mixture of nine bacteria) and FOS 50 ®) (10%) in the drinking water. The control groups received drinking water only. After 6 h of feed withdrawal, chickens were cooped (eight per coop) and held 10 h. Immediately after confinement, 10 chickens were used for cecal enumeration of *S. typhimuriumNR*. *Salmonella* colonization declined from 99% at 3 wk to 44% at 5 wk. After feed withdrawal, application of the treatment, and confinement, 11 and 14% of the treated and control groups, respectively, yielded *S. typhimuriumNR* by direct plating from ceca (3.87 and 3.75 log 10 cfu/g, respectively). No difference ($P > 0.05$) in *Salmonella* colonization occurred between the treated and the control groups; however, enrichment of ceca (incubation in nutrient broth at 37 C for 24 h) yielded a higher incidence of *S. typhimuriumNR* in the control groups (32% in the treated vs 51% in the control). Ceca weights were greater in the treated group ($P < 0.05$). Simulated feed withdrawal and confinement did not escalate *Salmonella* colonization in the chicken ceca.

Descriptors: *Diet--veterinary--VE; *Food Deprivation--physiology--PH; *Lactobacillus --physiology--PH; *Oligosaccharides--pharmacology--PD; *Poultry Diseases --prevention and control--PC; *Salmonella--growth and development--GD; *Salmonella Infections, Animal--prevention and control--PC; Cecum--microbiology--MI; Chickens; Diet--standards--ST; Drinking --physiology--PH; Eating--physiology--PH; Enterococcus faecium--isolation and purification--IP; Enterococcus faecium--physiology--PH; Lactobacillus --isolation and purification--IP; Lactococcus lactis--isolation and purification--IP; Lactococcus lactis--physiology--PH; Oligosaccharides --administration and

dosage--AD; *Pediococcus*--isolation and purification --IP; *Pediococcus*--physiology--PH; Poultry Diseases--diet therapy--DH; Poultry Diseases--physiopathology--PP; *Propionibacterium*--isolation and purification--IP; *Propionibacterium*--physiology--PH; *Salmonella*--isolation and purification--IP; *Salmonella* Infections, Animal--diet therapy--DH; *Salmonella* Infections, Animal--physiopathology--PP; *Salmonella typhimurium* --isolation and purification--IP; Water Microbiology

Palmu L; Camelin I (1997). **The use of competitive exclusion in broilers to reduce the level of *Salmonella* contamination on the farm and at the processing plant.** *Poultry Science* 76(11): 1501-1505.

NAL Call Number: 47.8 Am33P

The effect of a competitive exclusion (CE) product, Broilact, on *Salmonella* contamination of broiler chickens was studied on the farm and at the processing plant. In the first part of the study, two flocks per week, a CE-treated and an untreated control flock, were placed in similar broiler houses. The CE treatment was administered in the hatchery using a modified spray vaccination cabinet. *Salmonella* was analyzed from the paper pads of the transport boxes on arrival at the farm and from fecal samples taken 2 wk before slaughter. The results of *Salmonella* sampling were received for 67 flocks. The other 141 flocks of the company that were reared during the trial period were also sampled for *Salmonella* and the results were compared to those of treatment and control groups. Broiler performance, including mortality, weight, and feed conversion, was recorded for the trial flocks. In the second part of the study, *Salmonella* contamination of neck skin samples taken at the processing plant from 18 CE-treated and 28 control flocks was compared. The Broilact®-treatment significantly reduced *Salmonella* contamination both on the farm and at the processing plant. At the level of the farm, the percentage of *Salmonella*-positive flocks was essentially the same in the control flocks and in other flocks reared during the trial period. An improvement in broiler performance was indicated, although the difference was not significant.

Descriptors: poultry, *Salmonella*, farm hygiene, slaughter hygiene, field trial

Pimentel JL; Cook ME; Greger JL (1991). **Immune response of chicks fed various levels of zinc.** *Poultry Science* 70(4): 947-954.

University of Wisconsin, Department of Poultry Science, 1675 Observatory Drive, Madison, WI 53706, USA.

NAL Call Number: 47.8 Am33P

In 5 experiments, the effects of zinc intake on immune response of chicks was studied. 144 Ancona chicks (experiment 1), 180 New Hampshire (experiment 2), 88 New Hampshire X Leghorn (experiment 3), and 280 broiler chicks (experiments 4 and 5) were fed semipurified (experiments 1, 2, 3 and 4) or maize and soyabean meal diets (experiment 5) containing Zn from 8 to 88 μ g/g of diet. An extra group of chicks in experiments 1, 2 and 4 were fed on a diet adequate in Zn, but pair fed to intakes of chicks fed the lowest Zn level in each respective experiment. Low Zn intake (less than 28 μ g/g of diet) suppressed body weight at all times measured. The effect of Zn intake on the size of lymphoid tissues was variable, but at 5 weeks old, chicks given Zn 8 μ g/g of diet had smaller bursae of Fabricius and thymi than

those given additional Zn. Zn intake had no influence on primary and secondary immune response to sheep red blood cells or delayed hypersensitivity to phytohaemagglutinin-P (PHA) or human gamma globulin in Ancona and broiler chicks. However, Zn intake did have a small effect in chicks with New Hampshire parents. In experiments 1, 2 and 4 (at least at certain times), antibody titres were reduced in pair-fed chicks. Thus, although Zn supplementation at the levels of practical diets did not affect immune function, feed restriction did.

Descriptors: immune response, restricted feeding, zinc intake

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Porter RE; Holt PS (1993). **Effect of induced molting on the severity of intestinal lesions caused by *Salmonella enteritidis* infection in chickens.** *Avian Diseases* 37(4): 1009-1016.

U.S. Department of Agriculture, Southeast Poultry Research Laboratory, Athens, Georgia
NAL Call Number: 41.8 Av5

A study was conducted to describe the intestinal lesions caused by *Salmonella enteritidis* infection in 20-, 40-, and 74-week-old white leghorn chickens that were undergoing a feed deprivation-induced molt. The chickens were infected on the fourth day after feed was removed. At 4 days postinfection (8 days of feed deprivation), cecal and cecal tonsil inflammation was significantly greater in molted infected chickens than in unmolted infected chickens. The cecal lamina propria and epithelium of molted infected chickens contained heterophilic infiltrates, and there were heterophils and sloughed epithelial cells in cecal lumina. Colonic inflammation, consisting of heterophils infiltrating lamina propria and epithelium, occurred more often in molted infected chickens than in unmolted infected chickens. Immunoperoxidase staining of intestinal sections from 20- and 40-week-old chickens revealed *S. enteritidis* antigen in the lamina propria of cecum, cecal tonsil, and occasionally the colon of molted infected chickens. The character of the *S. enteritidis*-induced intestinal lesions associated with molting was similar for different ages of birds.

Descriptors: chickens, salmonella enteritidis, disease course, intestines, histopathology, molting, restricted feeding, age differences

Porter RE Jr; Holt PS (1992). **Effect of induced molting on the intestinal lesions caused by *Salmonella enteritidis* in different aged hens.** *Poultry Science* 71(Suppl.1): 169.

USDA/ARS, Southeast Poultry Research Laboratory, Athens, GA. 30605

NAL Call Number: 47.8 Am33P

Descriptors: bacteria, microorganism, starvation, poultry industry, feed industry

Praharaj NK (1996). **Nutrition and the immune response in chickens.** *Indian Journal of Poultry Science* 31(1): 1-5.

Project Directorate on Poultry, Rajendra Nagar, Hyderabad - 500 030, India.

NAL Call Number: SF481 I5

The effects of feed restriction and nutrients (energy, amino acids, vitamins and minerals) on immune response in chickens are reviewed. Nutrient requirements of the immune system are different from those of other body tissues. Therefore, immunosuppression may occur when

nutrient requirements are based on criteria, such as genetic stock, body weight gain, rate of production and husbandry practices. In the formulation of diets, attention should be given to requirements of those nutrients that are associated with the development of the immune system and the degree of protection required against diseases.

Descriptors: immune response, nutrition, restricted feeding, immunity, nutrient requirements, reviews

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Ramirez GA; Sarlin LL; Caldwell DJ; Yezak CR Jr.; Hume ME; Corrier DE; DeLoach JR; Hargis BM (1997). **Effect of feed withdrawal on the incidence of *Salmonella* in the crops and ceca of market age broiler chickens.** *Poultry Science* 76(4): 654-656.

Texas Agricultural Experiment Station, College Station, Texas

NAL Call Number: 47.8 Am33P

Previous research regarding *Salmonella* contamination in poultry has focused predominantly on cecal and intestinal contamination. Recently, the crop has been implicated as an important source of carcass contamination within the processing plant. In the present study, broiler chickens were orally challenged with 1×10^8 cfu *S. enteritidis* at 6 wk of age. At 7 wk of age, birds were randomly divided into two groups consisting of full access to feed, or total feed withdrawal, 18 h prior to sample collection. At the time of sample collection, crops and ceca were aseptically removed and cultured for the presence or absence of *S. enteritidis* by enrichment. The incidence of *S. enteritidis*-positive crops was consistently higher (range: 2.8- to 7.3-fold increases) following feed withdrawal than the incidence in samples collected from full-fed broilers in four experiments. Similarly, the incidence of *S. enteritidis* isolation was consistently higher (range: 1.4- to 2.1-fold increases) in ceca following feed withdrawal than in samples collected from full-fed broilers in these experiments. In a subsequent experiment, ceca and crops were aseptically collected and cultured for the presence of *Salmonella* immediately prior to or following 8 h feed withdrawal at a commercial broiler house. Similar to the laboratory experiments, the incidence of *Salmonella* isolation was significantly ($P < 0.01$) greater from crops following feed withdrawal (36/100) than from samples obtained immediately prior to withdrawal (19/100). However, the incidence of *Salmonella* in the ceca was not significantly higher following feed withdrawal (31/100) than in samples obtained immediately prior to withdrawal (25/100) in this field experiment. These studies indicate that feed withdrawal increases the incidence of *Salmonella* in broiler crops prior to slaughter and provide further evidence that the crop may be an important critical control point for reducing *Salmonella* contamination of broiler carcasses.

Descriptors: broilers, salmonella enteritidis, oral administration, experimental infection, crop, food deprivation, starvation, cecum, slaughter

Rigby CE; Pettit JR (1981). **Effects of feed withdrawal on the weight, fecal excretion and *Salmonella* status of market age broiler chickens.** *Canadian Journal of Comparative Medicine* 45(4): 363-365.

Anim. Path. Lab., 116 Veterinary Rd, Saskatoon, Saskatchewan S7N 2R3, Canada.

NAL Call Number: 41.8 C162

In 7-week-old fowls, previously infected with *S. typhimurium*, withdrawal of feed for 8 hours before being crated for 18 hours (to simulate transportation), had little effect on live weight, but reduced intestine weight in 84 of 120 birds, and caecal weight in 60 of 132; it greatly reduced faecal excretion, but there was no consistent effect on salmonella excretion. Feed withdrawal may be an effective means of reducing the spread of salmonella through faecal contamination during transport.

Descriptors: bacterial diseases, feces, poultry, epidemiology, food deprivation, transport of animals, poultry diseases, salmonellosis, fecal transmission

Rigby CE; Pettit JR (1979). **Some factors affecting *Salmonella typhimurium* infection and shedding in chickens raised on litter.** *Avian Diseases* 23(2): 442-455.

Anim. Dis. Res. Inst., PO Box 11300, Station H, Ottawa, Ontario K2H 8P9, Canada
NAL Call Number: 41.8 Av5

Inapparent *Salmonella typhimurium* (S.t.) infection of chickens placed at different ages on contaminated pinewood-shaving litter was studied in three sequential trials. Infection spread rapidly through chicks on new litter contaminated by infected seeders. As the flock matured, fewer birds were infected, and the number of organisms in their caeca and faeces decreased. After 87 days, 36/59 were infected, 7 were shedding, and the litter contained 104 S.t. per g. 30 three-day-old chickens placed on this litter readily became infected; 28 days later, although the number of S.t. in the litter had fallen to 102/g, 28/80 birds were infected, and 8 were shedding. Two days later, 63-day-old chickens were placed on this 131-day-old litter, and 32 days later, 41/50 birds were infected and 23 were shedding, although the litter contained only 102 organisms/g. Removing infected 24-day-old chicks to a wire cage hastened the age-related decline in faecal excretion of S.t. Subjecting chickens to "transport stress" (crowding, motion, chilling, and food and water deprivation) did not increase shedding or detectable infection, although the average weights of both caecal and cloacal contents increased.

Descriptors: bacterial diseases, transport of animals, epidemiology, age, floor husbandry, poultry, litter, salmonellosis, excretion of salmonella, salmonella contamination, infection in fowl

Rozak; Ungerer T; Nasution SH (1992). **Effect of stress from feed and drinkwater restriction on hormone level and body resistance reaction of chickens. [Pengaruh stress pengurangan makanan dan minuman terhadap kadar hormon dan kadar reaksi alat pertahanan tubuh].** *Gema Penelitian* 5(1): 17.

NAL Call Number: S471 I5G45

Descriptors: chickens, feed consumption, starvation, water deprivation, forced moulting, stress, antibodies, leukocytes, erythrocytes, biological development, birds, blood, blood cells, cells, consumption, domestic animals, domesticated birds, feeding, galliformes, immunological factors, immunology, livestock, moulting, poultry

Ruszler PL (1998). **Health and husbandry considerations of induced molting.** *Poultry Science* 77(12): 1789-1793.

Virginia Polytechnic Institute and State University, Blacksburg, VA.

NAL Call Number: 47.8 Am33P

There have been many methods proposed to induce molting. Some worked very well in practice, but others were detrimental to the health and welfare of the hens. The most effective methods use some level of feed restriction and daylength manipulation to reduce body weight (Hansen, 1966; Ruszler, 1974, 1984, 1996; Swanson and Bell, 1974; Brake and Carey, 1983). Weight reduction is necessary for rest and rejuvenation of body tissues. Other methods evaluated incorporated dietary imbalances using either zinc, iodine, or sodium.

Pharmaceuticals have been used but have not been cost effective. In recent years there have been those who question whether molting techniques are humane. Therefore, interest has been heightened in alternate methods to induce molting. Research reported to date has been inadequate to accurately determine which methods of induced molting are the least stressful, if they in fact, cause any more stress than that experienced by the hen during a natural molt. The three or four most highly refined methods being used commercially are not generally detrimental to the health and welfare of today's laying hen, provided that they are managed in accordance with proper husbandry practices.

Descriptors: hens, molting, starvation, duration, animal welfare, restricted feeding, protein intake, weight losses, light regime, oyster shells, calcium, laying performance

Saeed AM; Gast RK; Potter ME; Wall PG (eds.) (1999). ***Salmonella enterica serovar Enteritidis in humans and animals: epidemiology, pathogenesis, and control***, Iowa State University

Press: Ames, Iowa, 443 p. ISBN: 0-8138-2707-8

NAL Call Number: RA644 S15 S23 1999

This book was prepared with the help of 84 international scholars and scientists. A wide coverage of the epidemiology of *Salmonella enterica* serovar Enteritidis is given in 4 parts. Part 1, *Salmonella enterica* serovar Enteritidis epidemiological and public health considerations: a global prospective, has 12 chapters on the epidemiology in the UK, United States, France, Germany, Denmark, Netherlands, Switzerland, Austria, and Italy. The second part, Molecular epidemiology, has 4 chapters on methods of differentiation, molecular markers, phenotypic and genotypic characterization and molecular biological markers. Part 3, Virulence and pathogenesis, has 7 chapters on virulence, contamination of eggs and poultry, vertical transmission, phage type and outer membrane protein characteristics, experimental infection models, and the role of fimbriae in pathogenesis. Part 4, Prevention and control, has an introduction and 15 chapters. These cover economic consequences of infection in man and on the US egg industry, disease control in Sweden, the US National Poultry Improvement Plan, epidemiology in UK flocks, infection in poultry and rodents in the US, prevalence in unpasteurized eggs and aged laying hens, the Pilot Project in Pennsylvania, USA, the effect of induced moulting on immunity in hens, transmission caused by stress in hens, competitive exclusion, immunization and immunoprophylaxis, and culture methods for isolation of *S. enterica* serovar Enteritidis. Papers are well illustrated with diagrams and maps. There is an index.

Descriptors: zoonoses, public health, eggs, poultry, disease control, epidemiology

Seo KH; Holt PS; Gast RK; Hofacre CL (2000). **Combined effect of antibiotic and competitive exclusion treatment on *Salmonella enteritidis* fecal shedding in molted laying hens.** *Journal of Food Protection* 63(4): 545-548.

NAL Call Number: 44.8 J824

U.S. Department of Agriculture, Agricultural Research Service, Southeast Poultry Research Laboratory, Athens, Georgia 30605, USA.

Salmonella enteritidis is an important pathogen for the layer industry, primarily because of its ability to infect hens and ultimately contaminate egg contents. Studies have shown that stress situations, such as flock recycling (induced molting), can increase *Salmonella Enteritidis* problems in the flock. The present study examined the effect of antibiotic treatment and competitive exclusion (CE) on *Salmonella Enteritidis* shedding in the period following molt and 14-day feed withdrawal. In two separate trials, 48 birds after molt and feed withdrawal were divided into one group that was treated for 10 days with enrofloxacin in water followed by administration of CE culture and a group that was left untreated. *Salmonella Enteritidis* shedding was significantly reduced in the antibiotic-CE group. The *Salmonella Enteritidis* shedding rate was 33 and 25% in untreated birds versus 4 and 0% in the enrofloxacin-CE group on the two test days. These results indicate that treatment of *Salmonella Enteritidis*-positive laying hens after molting with enrofloxacin and CE culture can substantially reduce *Salmonella Enteritidis* problems due to molting and would be a possible alternative to diverting eggs for pasteurization or slaughtering the infected flock. Possible development of bacterial resistance in conjunction with antibiotic use is also discussed. Descriptors: hens, salmonella enteritidis, shedding, poultry droppings, enrofloxacin, drug therapy, cell cultures, time, molting, restricted feeding, salmonellosis, competitive exclusion cultures, feed withdrawal, induced molting, intestinal shedding

Seo KH; Holt PS; Gast RK (2001). **Comparison of *Salmonella enteritidis* infection in hens molted via long-term feed withdrawal versus full-fed wheat middling.** *Journal of Food Protection* 64(12): 1917-1921.

USDA/ARS Southeast Poultry Research Laboratory, Athens, Georgia 30605 USA.

NAL Call Number: 44.8 J824

Molting is an important economic management tool for the layer industry as a means of maximizing the effective laying life of a flock. Previous work has shown that molting birds through feed removal (FM) increased the severity of a *Salmonella Enteritidis* (SE) infection. The current study was conducted to follow the progression of an SE infection in unmolted hens versus hens molted via 14-day FM or ad libitum feeding of wheat middlings (WM), in the presence or absence of 2.5% lactose administered in the drinking water. In two trials of the experiment, all hens were infected with approximately 1×10^7 SE at day 4 of molt and sampled for SE shedding on days 4, 10, 17, and 24 postinfection (PI). Organ levels of SE were determined on day 7 PI. All molt procedures caused cessation of egg lay within 3 to 7 days. In trials 1 and 2, birds subjected to total FM shed 3 to 5 logs more SE than either the control birds (unmolted) or the birds fed WM on days 4 and 10 PI. Liver and spleen, ovary, and cecum counts were also significantly ($P < 0.05$) higher in the fasted birds in one trial and liver and spleen and cecum counts in the second. No differences in any of the SE counts were

observed in unmolted versus WM-fed birds. Lactose supplementation in drinking water did not provide any advantage in reducing SE infection in either trial. These results indicate that there are alternative methods to long-term FM that can be used to molt birds and not increase the risk for SE problems. How these alternative methods compare with FM with regard to second-cycle egg production and the mechanisms involved in the reduced SE shedding remain to be investigated.

Descriptors: *Chickens--physiology--PH; *Poultry Diseases--microbiology--MI; *Salmonella Infections, Animal--transmission--TM; *Salmonella enteritidis--isolation and purification--IP; Animal Feed; Animal Husbandry--methods--MT; Colony Count, Microbial; Eggs; Feces--microbiology--MI; Food Deprivation; Poultry Diseases--epidemiology --EP; Poultry Diseases--transmission--TM; Recurrence; Salmonella Infections, Animal--epidemiology--EP; Salmonella Infections, Animal --microbiology--MI; Time Factors

Shcherbina PF (1986). **Natural stressor resistance of hens of different genotypes with combs of different shapes.** *Soviet Agricultural Sciences* 4: 68-72. [Translated from: Vsesoiuznaia akademiia sel'skokhoziaistvennykh nauk, Doklady, (4), 1986, p. 38-40.]

NAL Call Number: S1.S68

Descriptors: hens, genotypes, stress, resistance, molting, forced molting

Souza ERN de (2000). **Study of the presence of *Salmonella* sp in layers submitted to forced moulting [Estudo da presença de *Salmonella* sp em poedeiras submetidas a muda forçada].** *Thesis Degree: Tese (Mestre em Microbiologia dos Alimentos)*, Universidade Federal de Lavras, MG (Brazil), 37 p.

Availability: CENAGRI, CP 02432, 70043-900 Brasilia, DF - Brazil.

Descriptors in English: layer chickens, forced moulting, salmonella, rations, eggs, microbiological analysis, infection, animal husbandry methods, animal products, bacteria, biological analysis, birds, chickens, disease transmission, domestic animals, enterobacteriaceae, galliformes, livestock, pathogenesis, poultry

Tellez GI; Jaeger L; Dean CE; Corrier DE; DeLoach JR; Williams JD; Hargis BM (1993). **Effect of prolonged administration of dietary capsaicin on *Salmonella enteritidis* infection in leghorn chicks.** *Avian Diseases* 37(1): 143-148.

NAL Call Number: 41.8 Av5

The effect of 14 or 19 days of dietary capsaicin (18 ppm) on *Salmonella enteritidis* infection and histological, morphometric, and pH changes of the ceca was investigated. At day 13 or day 18, chicks were challenged with 10(8) colony-forming units of *S. enteritidis*. Chicks were killed and cultured 24 hours later. The total number of *S. enteritidis*-organ-culture-positive chicks was significantly lower among chicks fed capsaicin for either 14 or 19 days than among controls ($P < 0.05$). Subjective histological examination revealed a mild to moderate infiltration of mononuclear cells and heterophils in lamina propria of ceca, as well as epithelial cell proliferation in chicks following either 14 or 19 days of capsaicin administration. Using morphometric analysis, the mean lamina propria thickness and mean epithelial cell thickness in chickens fed capsaicin for 14 or 19 days were significantly greater

than in controls ($P < 0.05$). Capsaicin significantly decreased luminal pH in both trials ($P < 0.05$). These data indicate that the observed capsaicin-induced resistance to *S. enteritidis* organ invasion is associated with measurable pH and morphological changes of the cecal mucosa.

Descriptors: chicks, capsaicin, *Salmonella enteritidis*, colonization, cecum, histopathology, pH, intestinal mucosa

Terachi H; Tanimoto A; Otani Y; Yano M; Sumii K; Takahashi M (1999). **Food hygienic countermeasure against hen's eggs contaminated with *Salmonella enteritidis*.** *Hiroshimaken Jui Gakkai Zasshi (Hiroshima Journal of Veterinary Medicine)* 14: 107-112.

Descriptors: chicken egg, *Salmonella enteritidis*, food hygiene, survey on actual situation, chicken raising, animal hygiene, food distribution, microorganism test, storage stability

To S; Nagino K; Kuroda N; Goto K (1998). **Field Experiences with Monitoring and Reducing *Salmonella* in Layer Farms.** *Keibyo Kenkyu Kaiho (Journal of the Japanese Society of Poultry Diseases)* 34, zokango: 7-11.

Descriptors: laying hen, *Salmonella*, animal hygiene, *Salmonella enteritidis*, antibacterial drug, *Lactobacillus* preparation, rearing management, cleaning(purification), pathogen control, Fukuoka prefect, forced molting

U.S. Department of Agriculture, Food Safety and Inspection Service (1998). ***Salmonella Enteritidis Risk Assessment: Shell Eggs and Egg Products. Final Report.***

Available at: <http://www.fsis.usda.gov/OPHS/risk/index.htm>.

NAL Call Number: aQR201 S25S25 1998

Weinack OM; Snoeyenbos GH; Soerjadi-Liem AS; Smyser CF (1985). **Influence of temperature, social, and dietary stress on development and stability of protective microflora in chickens against *S. typhimurium*.** *Avian Diseases* 29(4): 1177-1183.

Dep. Vet. Anim. Sci., Univ., Amherst, MA 01003, USA.

NAL Call Number: 41.8 Av5

In the 1-day-old chick, physiological stress in the form of high (40.6-43 deg C) or low (10-16 deg C) temperatures of feed and water deprivation either interfered with colonization or altered the protection provided by the normal intestinal microflora against subsequent challenge with *S. typhimurium*. The response was more obvious after individual exposure of chicks to salmonella than after exposure to infected seeders. Physiological and dietary stress at 2 weeks of age did not appreciably alter the *S. typhimurium* excretion pattern in treated chicks. The protective microflora appeared to be stable under these stress conditions.

Descriptors: poultry, susceptibility, prevention, intestinal microorganisms, stress, salmonellosis, bacterial diseases, poultry diseases, *Salmonella* exclusion

Yamauchi K; Nakanishi U (1997). **Poultry farmers group making effort to produce safe eggs and sanitation guidance.** *Yokei no Tomo* 427: 21-24.

Miekenkitasekachikuhoken'eisho

Descriptors: chicken egg, laying hen, rearing management, animal hygiene, Salmonella, microorganism contamination, microorganism test, food hygiene, prevention of animal epidemic, Mie prefect

Zakia AMA; El-Khashab E; El-Nabarawi AM; El-Jaky J (1995). **Effect of light and food withdrawal on the broiler responses to heat stress and/or *Salmonella typhimurium* infection at early growing stage.** *Veterinary Medical Journal Giza* 43(4): 461-468.
Dept. of Hygiene, Husbandry and Zoonoses, Fac. Veg. Med., Zagazig University, Egypt
NAL Call Number: SF604 C13

Eight-day-old broilers were exposed to heat stress of 40 deg C for a period of 4 h each day for 4 days (1000-1400 h). The birds were inoculated with *S. typhimurium* at 9 days of age by intercrop instillation of 0.1 ml of 106 CFU. The birds were kept under good husbandry with ample floor area (200 cm width x 200 cm length x 210 cm height/pen). Birds were divided in 3 groups which received either no food (starting 2 h before the heat stress), no light or both available during the hot period, with uninfected controls for each regimen. Food and light withdrawal had no significant effect on body weight gains throughout the experiment. All treatments had decreased body weights at the end of the 2nd and 3rd week compared to the controls. Alleviating heat stress by light and food withdrawal showed a significant decrease in rate of reisolation of *S. typhimurium* from all internal organs of the infected birds. No significant differences were detected in weights of liver and spleen between all treatments and controls, whereas there was a significant difference in the weights of the Fabricius bursa between the treatments and controls. Mortality rate was highest in the *Salmonella*-infected birds (24%) and lowest (10%) in the heat stressed birds with access to food and light.

Descriptors: poultry, heat, stress, husbandry, weight gain, mortality, heat stress, lighting, food deprivation, bacterial diseases, *Salmonella typhimurium*

PRESS RELEASE

Hot Pepper May Prevent Salmonella In Poultry

October 29, 2001

Contact: Audrey McElroy

Department of Poultry Science, Virginia Polytechnic University

[Ed. Note: See also CSREES Reports for project report]

Adding capsaicin, the spicy component of peppers, to the diet of broiler chicks appears to increase their resistance to *Salmonella*, according to Audrey McElroy, poultry science researcher at Virginia Tech.

As a student, McElroy and her advisor got the idea of feeding hot pepper oil to chickens while they were eating hamburgers covered with jalapeno peppers. When they wondered why people like spicy food even though it often causes a runny nose and other ill effects, a Mexican student said that people in his country believe spices provide protection from disease.

The researchers hypothesized that a diet that included some form of hot peppers might protect

poultry from intestinal disease. Salmonella typically results in little to no observable illness in chickens, but can cause human illness.

They divided 1,530 chicks into three groups and fed each group a standard corn and soybean meal-based diet for 42 days. McElroy fed the plain feed to the first group, added five parts per million of pure capsaicin to second group's feed, and 20 parts per million to the third group's feed. She administered Salmonella enteritidis to the chicks at 21, 28, and 42 days of age. Both the low and the high level of capsaicin increased resistance to the Salmonella without adversely affecting feed consumption, weight gain, or the taste of the chicken when cooked.

"The capsaicin appears to cause a mild inflammation in the intestines," she says.

She's investigating the possibility that the capsaicin-induced inflammation might make it more difficult for the Salmonella to bind to the intestinal cells and, from there, to invade the blood, liver, and spleen.

"Or," she says, "it may be that the capsaicin acts on the intestine to recruit immune cells, which then fight off the Salmonella."

Her current research is designed to evaluate any observable effects of capsaicin directly on Salmonella in laboratory conditions the effects of capsaicin on the intestinal environment, and the most economical scheme of feeding capsaicin to poultry.

The poultry seem to have no objections to the taste or sting of the capsaicin.

Contact Dr. McElroy at 540-231-8750 or amcelroy@vt.edu.

Selected Websites

Agricultural Research Service, US Department of Agriculture Projects:

Detection And Control Of Salmonella Enteritidis In Poultry

http://nps.ars.usda.gov/projects/projects.htm?ACCN_NO=404010

Evaluation Of Strategies For Induced Molting On Salmonella Enteritidis Problems In Laying Flocks

http://nps.ars.usda.gov/projects/projects.htm?ACCN_NO=404430

Molecular Pathobiology And Epidemiology Of Egg-Contaminating Salmonella Enteritidis

http://nps.ars.usda.gov/projects/projects.htm?ACCN_NO=404087

Southeast Poultry Research Laboratory

<http://nps.ars.usda.gov/locations/locations.htm?modecode=66-12-07-00> (links to research projects)

<http://seprl.ars.usda.gov/> (laboratory homepage)

Commercial Egg Tip - The Induced Molt: A Critical Control Point for Hazard Minimization of *Salmonella enteritidis* Contamination of Eggs: University of Nebraska Cooperative

Extension

<http://nvdl.unl.edu/vnewslet/wint99.pdf>

Egg Industry Initiatives to Control *Salmonella*: TECHNICAL BULLETIN: A Publication of Hy-line International

http://www.hyline.com/tb_salm_e.pdf

Egg Safety From Production to Consumption: An Action Plan to Eliminate *Salmonella Enteritidis* Illnesses Due to Eggs December 10, 1999: President's Council on Food Safety

<http://www.foodsafety.gov/~fsg/ceggs.html>

Focus On Shell Eggs: Food Safety and Inspection Service

<http://www.fsis.usda.gov/OA/pubs/shelleggs.htm>

Good Management Practices for *Salmonella* Risk Reduction in the Production of Table Eggs: University of Minnesota Extension Service

<http://www.extension.umn.edu/distribution/livestocksystems/DI6054.html>

Joint FAO/WHO Activities on Risk Assessment of Microbiological Hazards in Foods. Risk Assessment: *Salmonella* spp. In Broilers and Eggs. Preliminary Report Prepared for Joint FAO/WHO Expert Consultation on Risk Assessment of Microbiological Hazards in Foods, FAO Headquarters, Rome, Italy, 17 - 21 July 2000

http://www.who.int/fsf/mbriskassess/Scientific_documents/mra04.pdf

The National Poultry Improvement Plan

<http://www.aphis.usda.gov/vs/npip/>

Poultry Health and Poultry Futures Programs

<http://www.aphis.usda.gov/vs/naahps/Poultry/health.htm>

Project No. 15: Effects of a Variety of Stress Factors on the Immune Systems of Poultry and Subsequent Infection of Shell Eggs by *Salmonella enteritidis*: US Food and Drug Administration, Center for Food Safety and Nutrition

<http://vm.cfsan.fda.gov/~dms/3fs3re15.html>

Public Meeting on *Salmonella enteritidis* Research Hapeville, Georgia, September 8, 2000, Transcript of Proceedings: U. S. Food and Drug Administration and U.S. Department of Agriculture

<http://www.foodsafety.gov/~dms/egg0900.html>

Report of the Committee on *Salmonella enteritidis* (SE) in Eggs: United States Animal Health Association

<http://www.usaha.org/reports/reports00/r00seegg>

Salmonella: Includes the following articles from the US Centers for Disease Control and Prevention's FoodNet:

- ☞ *Salmonella* Cost Estimate Update Using FoodNet Data.
- ☞ Phage Type and Antimicrobial Resistance Trends among Human *Salmonella serotype typhimurium* Infections, 1997-1998: Continued Dominance of DT104 R-Type ACSSuT.
- ☞ FoodNet 1996 to 1998: Data on Deaths and Invasive Illnesses Demonstrate the Severity of *Salmonella* and *Listeria*.
- ☞ Dramatic Decreases in *Salmonella serotype enteritidis* (SE) in FoodNet Sites, 1996-1998.
- ☞ Reading between Declines: Characteristics of the Decrease in Reported *Salmonella* Isolations within FoodNet, 1996-1998.
- ☞ Decline in *Salmonella* and *Campylobacter* but not *E. coli* O157 isolation rates in FoodNet sites: Farm, food, or fluctuation?
- ☞ Eggs identified as a risk factor for sporadic *Salmonella serotype heidelberg* infections: a case-control study in FoodNet sites.
- ☞ Chicken, a newly identified risk factor for sporadic *Salmonella serotype enteritidis* infections in the United States: A case-control study in FoodNet sites.

<http://www.cdc.gov/foodnet/pus/salmo.htm>

Salmonella Control And Molting Of Egg-Laying Flocks--Are They Compatible: University of Florida, Institute of Food and Agricultural Sciences

http://edis.ifas.ufl.edu/BODY_VM017

Salmonella enterica serotype enteritidis in Table Eggs-NAHMS Layers '99 (October, 2000)

<http://www.aphis.usda.gov/vs/ceah/cahm/Poultry/poult.htm>

Salmonella enteritidis and molting California Poultry Letter March/April 2001 Cooperative Extension - University of California at Davis

<http://animalscience.ucdavis.edu/Avian/cplmarch2001.pdf>

Salmonella enteritidis in Eggs. AGENCIES: Food Safety and Inspection Service, USDA; Food and Drug Administration, HHS.ACTION: Advance notice of proposed rulemaking; request for comments. Federal Register.

<http://www.fsis.usda.gov/OPPDE/rdad/FRPubs/97N-0322.htm>

United Egg Producers Re: Docket Nos. 98N-1230: comments following the FDA and FSIS joint meeting August 26, 1999 to discuss an action plan to address the presence of Salmonella enteritidis (SE) in shell eggs using a farm-to-table approach.

<http://www.fda.gov/ohrms/dockets/dailys/100199/c000509.pdf>

U.S. Poultry & Egg Association position papers: Induced Molting in the Layer Industry

http://www.poultryegg.org/About_USPOULTRY/Position_Papers/position_papers.html

Valuing Pain and Suffering and Lost Productivity: Measuring the Pain, Suffering, and Functional Disability Associated with Foodborne Illness (*Salmonella enteritidis* (SE) in shell eggs and egg products)

<http://www.ers.usda.gov/publications/mp1570/mp1570g.pdf>

POULTRY WELFARE

Aggrey SE; Kroetzl H; Foelsch DW (1990). **Behaviour of laying hens during induced moulting in three different production systems.** *Applied Animal Behaviour Science* 25(1/2): 97-105.

Swiss Federal Institute of Technology, Zurich, Switzerland

NAL Call Number: QL750.A6

This work is a critical investigation of how methods of moulting are practiced by farmers. Dekalb hens were fasted with a reduced photoperiod to induce moult and hence lengthen the total egg laying period in three housing systems, namely wire floor, multifloor (globovolg) and battery cages. The behaviour of the hens was compared with their behaviour during the production period. The hens were frustrated at the time of feed deprivation, leading to increases in object pecking, locomotion and negative social interaction activities in the wire floor and globovolg systems. The behaviour of hens in cages during both production and moulting periods did not show any changes. At 4 days of fasting, resting activity dominated and during the moulting period (when new feathers were pushing out old feathers), the hens were almost inactive.

Descriptors: hens, molting, fasting, photoperiod, locomotion, agonistic behavior, chicken housing

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Avrutina AYa; Shinkareva VP; Vol'pe NO; Frolova EG (1976). **Reaction of the adrenal system of the laying hen to the stress of starvation.** [Reaktsiya adrenalovoi sistemy kur-nesushek na stress golodaniya.] *Doklady Vsesoyuznoi Ordena Lenina Akademii Sel'skokhozyaistvennykh Nauk* (Proceedings of the Lenin Academy of Agricultural Sciences) (No. 4): 33-34.

Vsesoyuznyi –I inst. razvedeniya I genetiki Sel'skokhozyaistvennykh zhivotnykh, USSR

NAL Call Number: 20 Ak1

Leghorn hens were fed on a complete dry diet; daily egg production was measured. During the month before testing, sexual activity of the hens was assessed by mean frequency of mating during 24 h for 3 days. By age 14 months, the hens were subjected to starvation for 10 days, which induced moulting, then feed was reintroduced gradually. For the 10 days before starvation egg yield was, on average, 45.5%; on days 5 and 8 of starvation, yields were 14.3 and 0.93%, and by day 9 nil. Loss of weight was 15 to 20%. Plasma corticosterone was 7.99 plus or minus 0.45 μ g/100 ml before, on day 2 of starvation rose by 7.9% and by day 10 had dropped to 1.61 plus or minus 0.205 μ g/100 ml. During refeeding, the hormone concentration rose to 5.97 plus or minus 0.545 μ g/100 ml. In high-yielding hens with high sexual activity and in those with increased functional activity of the adrenals, compared with low-yielding hens and those with subdued sexual activity, there was a less sharp increase in corticosterone on day 2 of starvation. The findings could be used in selection of highly productive, stress-resistant lines of hens.

Descriptors: hens, starvation, corticosterone

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- Barnett JL; Newman EA (1997). **Review of welfare research in the laying hen and the research and management implications for the Australian egg industry.** *Australian Journal of Agricultural Research* 48(4): 385-402.
Victorian Institute of Animal Science, Vic., Australia.
NAL Call Number: 23 Au783
Descriptors: hens, animal welfare, battery husbandry, battery cages, animal health, debeaking, perches, enrichment, molting, restricted feeding, environmental temperature, handling, transport, slaughter, occupational health, farm workers, poultry industry, literature reviews, alternative cage systems, beak trimming, environmental enrichment
- Eskeland B (1981). **Anatomical modifications and induced moulting: effects of beak trimming [laying hens, pens, population density, group size, behaviour].** *First European symposium on poultry welfare: Report of proceedings*, Soerensen LY (ed.), World Poultry Science Association: Copenhagen (Denmark), p.193-200. ISBN: 87-88162-00-1
Norges Landbrukshoegskole, Aas. Dept. of Poultry and Fur Animals
NAL Call Number: HD9437 E9 1981
- Gentle MJ; Breward J (1981). **Anatomical modifications and induced moulting: the anatomy of the beak [chicken, trimming, Herbst corpuscle, Grandry corpuscle, taste buds].** *First European symposium on poultry welfare: Report of proceedings*, Soerensen LY (ed.), World Poultry Science Association: Copenhagen (Denmark), p.185-189. ISBN: 87-88162-00-1
Agricultural Research Council, Roslin, Midlothian, UK. Poultry Research Centre.
NAL Call Number: HD9437 E9 1981
- Gildersleeve RP; Johnson WA; Satterlee DG; Scott TR (1979). **Daily rhythms of plasma corticosterone in hens during production and before a forced molt.** *Poultry Science* 58(4): 1061.
Poultry Science Dep., Louisiana State Univ., Baton Rouge, LA 70803, USA.
NAL Call Number: 47.8 Am33P
Study was of plasma corticosterone in laying hens force-moulted by deprivation of feed. Plasma corticosterone was reduced in hens allowed short daily photoperiods, 6 h light daily. In hens allowed 19 h of light daily (LH) the rhythm of plasma corticosterone values during 48 h tended to have 4 peaks. LH hens seemed to have an indistinct rhythm of plasma corticosterone.
Descriptors: corticosterone, blood plasma, hens
Copyright© 2002, CAB International
- Hoshino S; Suzuki M; Kakegawa T; Imai K; Wakita M; Kobayashi Y; Yamada Y (1988). **Changes in plasma thyroid hormones, luteinizing hormone (LH), estradiol, progesterone and corticosterone of laying hens during a forced molt.** *Comparative Biochemistry and Physiology. A: Comparative Physiology* 90(2): 355-359.
NAL Call Number: QP1.C6
Descriptors: hens, blood plasma, thyroid hormones, LH, estradiol, progesterone, corticosterone, molt

Hussein AS (1996). **Induced moulting procedures in laying fowl.** *World's Poultry Science Journal* 52 (2): 175-187.

Department of Animal Production, Faculty of Agricultural Sciences, United Arab Emirates University, P.O. Box 17555, Al-Ain, United Arab Emirates.

NAL Call Number: 47.8 W89

Several methods of inducing moulting in laying hens are reviewed. Such methods are used to recycle laying hens, the majority of which require an optimum weight loss of 25-30% to achieve maximum egg production during the post-moulting period. The conventional feed restriction procedure is most often used in the egg industry because it is a simple, practical and economical technique that can be used in combination with light and/or water restriction. Mineral-induced moulting procedures, such as the use of high levels of either aluminum in the form of a soluble salt or dietary zinc, have also been used successfully. In addition, low concentrations of dietary Zn combined with a low-calcium diet have also induced moulting in laying hens. The use of low-sodium diets has also been as successful as the conventional feed restriction technique. Mineral-induced moulting procedures produce similar results to the conventional feed restriction techniques in post-moulting egg production, but with lower mortality rates; however, some of these procedures may not yet be practical for use in the egg industry. Hormone-induced moulting is another method and involves the use of the gonadotropin-releasing hormone agonist. It has an advantage over the conventional feed restriction procedure in that it does not require severe initial body weight loss to attain maximum egg production in the post-moulting period.

Descriptors: hens, molting, induction, weight losses, egg production, restricted feeding, mineral excess, aluminum, zinc, mineral deficiencies, calcium, sodium, GnRH, animal welfare, literature reviews

Jensen JF (1981). **Anatomical modifications and induced moulting: [egg-laying hens, egg-laying capacity, control of diseases, control of environment].** *First European symposium on poultry welfare: Report of proceedings*, Soerensen LY (ed.), World Poultry Science Association: Copenhagen (Denmark), p.165-173. ISBN: 87-88162-00-1
Statens Husdyrbrugsforsoeg, Copenhagen, Denmark. Afdeling for Fjerkrae og Kaniner
NAL Call Number: HD9437 E9 1981

Karunajeewa H (1987). **A review of current poultry feeding systems and their potential acceptability to animal welfarists.** *World's Poultry Science Journal* 43(1): 20-32.
Dep. Agric. Rural Affairs, Animal Res. Inst., Werribee, Victoria 3030, Australia
NAL Call Number: 47.8 W89

Descriptors: chicken, barley, protein, feed intake, growth, induced molting

Luk'yanov V; Baidevlyatov A; Tsinovyi V; Ol'khovik L; Kuznetsov M (1976). **A study of stress associated with the induction of moult in laying hens. [Ob otsenke stressa prinuditel'noi lin'ki u kur.]** *Ptitsevodstvo* (No. 8): 17-19.
Ukrainskii nauchno-issledovatel'skii institut pitsevodstvo, Kiev, Ukrainskaya SSR, USSR.
NAL Call Number: Z5074 P8R4

Trials were carried out on 18,000 laying hens with moult induced by (I) deprivation of food and water, (ii) deprivation of calcium, (iii) oral administration of "Evertas" (metallibure analogue), (iv) injection of testosterone and thyroxine. Methods (I) and (ii) induced a moult after 10-15 days, lasting for 20-50 days. A general loss in weight was observed 10-40 days after the start of treatment. Water deprivation reduced eggshell thickness. Method (iii) caused inappetence, loss of weight and depression. These effects lasted for about 50 days. The use of hormones (method iv) caused marked depression; many treated birds adopted a "penguin" stance, and the depression lasted about 3-4 days. The greatest mortality in the first month after treatment was in birds treated by methods (I) and (ii). Mortality was much lower in birds treated with "Evertas" or with hormones. All methods of malt induction caused initially a decrease in blood calcium, cholesterol, lipoproteins and ribonuclease activity; and an increase in blood proteins. During the later stages of moult these values returned to normal.

Descriptors: egg production, stress, hens, moulting

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Novidov BG; Garmatina SM; Danilova OV (1980). **Neuroendocrine mechanisms of stressor molting in birds.** *Doklady Biological Sciences, Proceedings of the Academy of Sciences of the USSR, Biological Sciences Sections* 247(1/6): 1042-1044.

NAL Call Number: 511 P444AEB

Descriptors: hens; hormonal control; moulting

Rolon A; Buhr RJ; Cunningham DL (1993). **Twenty-four-hour feed withdrawal and limited feeding as alternative methods for induction of molt in laying hens.** *Poultry Science* 72(5): 776-785.

The University of Georgia, Athens, GA

NAL Call Number: 47.8 AM33P

Alternative molting methods involving shorter periods of feed withdrawal and feeding a low-density and low-energy "molt diet" were compared to conventionally molted (8-day feed removal) and nonmolted hens. Alternative molt methods consisted of feeding the molt diet for 28 days for ad libitum intake, daily limited, or alternate-day limited (feeding every other day). Egg production, egg weight, specific gravity, body weight, feed intake, and mortality were recorded for 31 wk from the start of the molt (4 wk molt, 1 wk prelay, and 26 wk postmolt). Economic variables (feed cost, egg value, income over feed costs per hen housed) were compared between molting methods. Hens provided ad libitum access to the molt diet produced more eggs during the molt period than hens molted by other methods. Total egg production and income (egg value minus feed cost) were comparable among all molting methods and exceeded the values for nonmolted control hens. Income per hen housed was \$2.20 for nonmolted control, \$2.87 for the conventional, \$2.92 for ad libitum, \$2.81 for daily limited, and \$2.97 for the alternate-day limited hens. These results indicate that alternative molting methods involving periods of feed withdrawal of 24 h or less can be as economically effective as conventional methods using longer periods of feed withdrawal.

Descriptors: hens, restricted feeding, diet, molt, metabolizable energy, body weight, egg weight, egg production, mortality, feed intake, production costs, income, animal welfare, feed costs

Rozak; Ungerer T; Nasution SH (1992). **Effect of stress from feed and drinkwater restriction on hormone level and body resistance reaction of chickens.** [Pengaruh stress pengurangan makanan dan minuman terhadap kadar hormon dan kadar reaksi alat pertahanan tubuh]. *Gema Penelitian* 5(1): 17.

NAL Call Number: S471 I5G45

Descriptors: chickens, feed consumption, starvation, water deprivation, forced moulting, stress, antibodies, leukocytes, erythrocytes , biological development, birds, blood, blood cells, cells, consumption, domestic animals, domesticated birds, feeding, galliformes, immunological factors, immunology, livestock, moulting, poultry

Ruszler PL (1998). **Health and husbandry considerations of induced molting.** *Poultry Science* 77(12): 1789-1793.

Virginia Polytechnic Institute and State University, Blacksburg, VA.

NAL Call Number: 47.8 Am33P

There have been many methods proposed to induce molting. Some worked very well in practice, but others were detrimental to the health and welfare of the hens. The most effective methods use some level of feed restriction and daylength manipulation to reduce body weight (Hansen, 1966; Ruszler, 1974, 1984, 1996; Swanson and Bell, 1974; Brake and Carey, 1983). Weight reduction is necessary for rest and rejuvenation of body tissues. Other methods evaluated incorporated dietary imbalances using either zinc, iodine, or sodium.

Pharmaceuticals have been used but have not been cost effective. In recent years there have been those who question whether molting techniques are humane. Therefore, interest has been heightened in alternate methods to induce molting. Research reported to date has been inadequate to accurately determine which methods of induced molting are the least stressful, if they in fact, cause any more stress than that experienced by the hen during a natural molt. The three or four most highly refined methods being used commercially are not generally detrimental to the health and welfare of today's laying hen, provided that they are managed in accordance with proper husbandry practices.

Descriptors: hens, molting, starvation, duration, animal welfare, restricted feeding, protein intake, weight losses, light regime, oyster shells, calcium, laying performance

Ruszler PL; Minear LR (1997). **Comparison of induced molts using periods of four vs ten days feed withdrawal.** *Poultry Science* 76(Suppl. 1): 104.

Dep. Animal Poultry Sci., Virginia Tech., Blacksburg, Virginia 24061

NAL Call Number: 47.8 Am33P

Descriptors: body weight loss, commercial flocks, four versus ten days feed withdrawal, induced molts comparison, light exposure

Simonsen HB (1981). **Anatomical modifications and induced moulting: welfare aspects related to number of laying periods of hens [ethics, legislation, disease, mortality, physiology, behaviour].** *First European symposium on poultry welfare: Report of proceedings*, Soerensen LY (ed.), World Poultry Science Association: Copenhagen (Denmark), p.177-182. ISBN: 87-88162-00-1

Kongelige Veterinaer- og Landbohøjskole, Copenhagen, Denmark. Afdeling for Retsmedicin
NAL Call Number: HD9437 E9 1981

Taylor AA; Hurnik JF (1996). **The long-term productivity of hens housed in battery cages and an aviary.** *Poultry Science* 75(1): 47-51.

University of Guelph, ON, Canada.

NAL Call Number: 47.8 Am33P

This study examined the long-term effects of housing system on several aspects of laying hen production. At 19 wks of age, 336 White Leghorn hens were placed, 3 birds per cage, into battery cages; 437 birds were assigned to an aviary with communal nests, ambulation areas, and three raised tiers with feeders and drinkers. Family groups were split between the two housing systems. The hens were housed in such a manner for over 3 yr (until the end of the 168th wk of age), with forced molts between 66 and 74 and between 119 and 125 wk of age. Feed consumption and conversion, egg weight, eggshell deformation, and hen-day productivity were assessed monthly in both systems. Although feed consumption and conversion tended to be higher in the aviary throughout the study, these variables differed significantly due to housing system only in Year 2 ($P = 0.04$). There were no differences in egg weight ($P = 0.7$), eggshell deformation ($P = 0.85$), egg cracking during shaking ($P = 0.34$), total hen-day productivity ($P = 0.55$), or egg mass produced per hen per month ($P = 0.4$). Although aviary systems have been criticized for egg losses due to floor laying, only 2.5% of eggs in the current study were laid on the floor in Year 1, and 0.3% in Years 2 and 3; 1.7% across all years. Hen mortality was variable across production and molt periods, and did not differ due to housing system ($P > 0.05$). The results of this study confirm that hen productivity in well-managed alternative housing systems can compare favorably with that in battery cages.

Descriptors: hens, battery cages, aviaries, feed intake, feed conversion, egg weight, egg shell defects, laying performance, mortality, egg mass, animal welfare, unrestricted feeding

Vermaut S; de Coninck K; Onagbesan O; Flo G; Cokelaere M; Decuypere E (1998). **A jojoba-rich diet as a new forced molting method in poultry.** *Journal of Applied Poultry Research* 7(3): 239-246.

Laboratory of Physiology and Immunology of Domestic Animals, Katholieke Universiteit Leuven, K. Mercierlaan 92, B-3001 Heverlee, Belgium

NAL Call Number: SF481.J68

The use of jojoba meal for inducing molting, based on feed restriction was studied. Broiler breeder chickens were force-moulted by 12% jojoba meal supplementation in the diet resulting in higher egg production than before molting. This percentage of jojoba meal restricted feed intake to a level similar to that of chickens moulted by a well-established qualitative force-moulting method (UK Agricultural Development and Advisory Service's, involving a quantitative feed restriction of wheat only, combined with a reduced photoperiod). The regression of the oviduct during the molting period is probably due to the severe feed restriction itself, and is not a toxic effect of jojoba meal. The oviduct regrew

completely after withdrawal of jojoba meal. Jojoba meal thus has no irreversible inhibitory effect on regrowth of the oviduct of adult broiler breeders after moulting, whereas in growing pullets, jojoba meal is known to produce an irreversible inhibition of the oviduct development, resulting in no egg laying.

Descriptors: chickens, molting, restricted feeding, jojoba, animal welfare, anorexiant, chemical composition, body weight, laying performance, oviducts, length, weight, ovaries, photoperiod, feed intake

Wakeling DE (1977). **Induced moulting-a review of the literature, current practice and areas for further research.** *World's Poultry Science Journal* 33(1): 12-20.

ADAS, MAFF, Starcross, Devon, UK.

NAL Call Number: 47.8 W89

Descriptors: hens, animal physiology, reviews, molting, molt induction, poultry

Wang G; Zhu J; Zhao W; Yan J; Huang D; Li Z (1995). **Endocrine characteristics of moult induced by GnRH agonist in laying fowls.** *Jiangsu Journal of Agricultural Sciences* 11(1): 36-39.

Institute of the Application of Atomic Energy in Agriculture, Jiangsu Academy of Agricultural Science, Nanjing 210014, China

NAL Call Number: S539.5 C55

In hens treated with a GnRH agonist, plasma thyroxine concentration was significantly higher than in untreated, control hens, but there was no significant difference in triiodothyronine concentration. Plasma progesterone concentration was significantly lower, and oestradiol concentration was significantly higher, in treated than in control birds. Treatment with the agonist resulted in suspension of laying for 22 days. At the start of the next laying season, laying rate and egg weight did not differ significantly between treated and control birds.

Descriptors: moult, induction, GnRH, egg production, egg weight, thyroid hormones, sex hormones

Webster AB (2000). **Behavior of White Leghorn laying hens after withdrawal of feed.** *Poultry Science* 79(2): 192-200.

NAL Call Number: 47.8 Am33P

To approximate a commercially induced molt, feed was withdrawn (FW) from Hy-Line W-36 hens (65-wk-old) until they lost 35% of their initial body weight. Behaviors of 36 FW hens and 36 control hens were video recorded on Days 1 to 3, 8 to 10, and 19 to 21 of FW, when FW hens reached 15, 25, and 35% body weight loss. The FW hens then were fed a pullet grower ration until Day 28 after the start of FW, whereupon they were provided a layer ration. Second cycle production of FW hens to 40 wk postmolt initiation averaged 15.5 dozen eggs/hen housed. The FW hens manifested increased aggression on the first d of FW, perhaps indicative of frustration, and then exhibited increased standing, head movement, and nonnutritive pecking on Day 2, followed by reduction of these actions on Day 3. Resting behavior was observed 24 and 40% of the time for FW hens on Days 8 to 10 and 19 to 21 of the FW period, respectively. Nonnutritive pecking was higher for FW hens than for control

hens throughout the FW period. Preening was more frequent for FW hens on Days 8 to 10, probably due to skin sensitivity near the start of feather push out, which began on Day 11. Behavior during the feed withdrawal period was consistent with conservation of bodily reserves, but FW hens never lost their capability for alertness and reactivity. The FW hens had significantly lower mortality during the study than control hens (2 vs 12%, respectively). Descriptors: hens, body weight, starvation, weight losses, molting, mortality, laying performance, animal behavior, rest, aggressive behavior, preening, pecking

Selected Websites

American Veterinary Medical Association Position on Induced Molting in Layer Hens
<http://www.avma.org/care4pets/polpoul.htm>

Burger King Imposes Animal Welfare Rules
http://www.agjournal.com/story.cfm?story_id=1341

Canadian Veterinary Medical Association Animal Welfare Position Statement on Forced Molting of Chickens
<http://www.cvma-acmv.org/welfare1.asp?subcat=Priorities&num=24>

Food Marketing Institute (FMI) and the National Council of Chain Restaurants (NCCR) Animal Welfare Program June 2002 Report
http://fmi.org/animal_welfare/62602finalrpt.pdf
Force-molting Studies with an Emphasis on Animal Welfare at Cornell University
<http://www.ansci.cornell.edu/faculty/keshavarz/curr-res.html>

Forced Molting of Laying Birds
<http://www.poultry.org/molting.htm>

Induced Molting Resolution Fails, but Delegate Support for Alternatives Grows. Journal of the American Veterinary Medical Association, September 1, 2001
<http://www.avma.org/onlnews/javma/sep01/s090101i.asp>

McDonald's Corporation Animal Welfare Issues Update Laying Hens - Goals and Objectives
http://www.mcdonalds.com/countries/usa/community/welfare/laying_hen/laying_hen.html

Molting, Bird Density, and Animal Welfare by Ken W. Koelkebeck, University of Illinois
<http://poultrynet.outrreach.uiuc.edu/fulltext.cfm?section=2&documentID=13>

Research on Alternative Molting Methods California Poultry Letter September/October 2001, Cooperative Extension Service, University of California at Davis
<http://animalscience.ucdavis.edu/Avian/cplsepoct01.pdf>

The Welfare of Poultry: Review of Recent Literature by Karen Schwean, Department of Animal and Poultry Science, University of Saskatchewan

<http://adminsrv.usask.ca/psci/PSCI2001/pdf/welfare/poultry.pdf>

Wendy's Animal Welfare Program Fact Sheet: Chicken Supplier Requirement

<http://www.wendys.com/animal-welfare2.html>

MANAGEMENT STRATEGIES

ECONOMICS

Bell D (2000). **Economics of alternative replacement programs.** *World Poultry* 16(6): 30-35.

Department of Animal Science, University of California, Riverside, California

NAL Call Number: SF481 M54

The paper discusses the factors involved in analyzing whether induced moulting, as part of a layer replacement programme, can increase economic returns over those from all-pullet programmes. Because of the complex interrelationships involved, it cannot be stated conclusively that recycling is economically better or worse than an all-pullet programme. With accurate performance and pricing information, and the use of a computer, the final answer can be determined for each set of conditions. The impacts of the elimination of induced moulting on the US egg industry are highlighted.

Descriptors: pullets, hens, moulting, replacement, economic analysis, economics, optimization, profitability, egg production, poultry

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Bondarev EI; Popova LA; Andrushchenko NA (1998). **Extension of production period of utilizing laying hens of commercial flock by forced molting.** *Izvestiya Timiryazevskoi*

Sel'skokhozyaistvennoi Akademii (3): p 161-171. ISSN: 0021-342X

Dep. Poult. Breed., K. A. Timiryazev Mosc. Agric. Acad., Moscow, Russia

The effect of different schemes of forced molting on productivity of commodity laying hens of P-46 cross under intermittent and non-intermittent lighting has been studied. By a number of characteristics, including economic ones, 2 schemes of forcing molting in poultry appeared to be most efficient: fasting for 9 days under intermittent lighting and fasting for 6 days followed by alternation of three days of fasting with days of limited feeding hens under regime of non-intermittent lighting.

Chen LH; McNaughton JL; Malone GW (1982). **A system approach to determining the feasibility of forced molting commercial layers.** *Poultry Science* 61(6): 1029-1036.

Agricultural Biological Engineering Dep., MAFES-Mississippi State Univ., Mississippi State, Mississippi

NAL Call Number: 47.8-AM33P

The economical and practical considerations in determining the feasibility of molting a commercial layer flock are based on several production and economical factors. A computerized model used to predict: the economic feasibility of molting when layers are in various production periods; the net profit resulting from different molting procedures and the effect of increased feed cost on profit is described. Forced laying hen molt resulted in higher net profit for 2 different molt regimens than for the no-molt alternative. Based on the fixed inputs, the molt procedure employed resulted in different net revenues. The situation and assumed conditions evaluated represented several alternatives to commercial producers. The model is designed to generally evaluate the feasibility of molting at various ages. The

reliability of using a computer model to predict molt or no-molt alternatives is dependent on accurate data inputs.

Descriptors: laying hens, production factors, economic factors, computer modeling, environmental temperature, stage of production, molting strategies, feed costs, net profit
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Cunningham DL; McCormick CC (1985). **A multicycle comparison of dietary zinc and feed removal molting procedures production and income performance.** *Poultry Science* 64(2). 1985. 253-260

Dep. Of Poultry And Avian Sciences, Cornell University, Ithaca, NY 14853.

NAL Call Number: 47.8 Am33P

Two experiments were conducted to evaluate performance and income factors associated with ZnO and feed removal multicycle molt programs. Experiment 1 compared 2 strains of commercial White Leghorn layers molted with 20,000 ppm ZnO in the feed for 4 days with a feed removal program of 10 days followed by 10 days of cracked corn. Experiment 2 compared a single strain of White Leghorn layers molted with 20,000 ppm ZnO with feed removal for 4 and 10 days. Body weight loss during molt averaged 25-30% for the longer duration molt programs compared to 14-16% for the short duration programs. Differences on body weight loss between ZnO and feed removal programs employing the same durations of treatment were not significant ($P < 0.05$). No significant ($P < 0.05$) differences were observed between ZnO and feed removal programs for hen-housed egg production, days to reduce egg production to 0%, feed usage or mortality rates. Differences in egg size and egg grade distributions were observed among molting programs and strains. Incomes over pullet and feed costs for the molted flocks were greatest during the 1st molt cycle. Incomes over pullet and feed cost during the 2nd molt cycle were generally negative. The longer duration molt programs resulted in total incomes over feed and pullet costs averaging 5.0.cents./doz more than the shorter 4 day duration programs. Duration of molt-inducing periods had greater effects on performance and income results than did the method used to induce rest.

Descriptors: white leghorn chicken, corn, metabolic-drug, egg production, pharmacodynamics

Douglas CR; Christmas RB; Ford SA (1989). **An economic analysis of molting systems including length of fast age and multiple molts.** *Poultry Science* 68(Suppl.1): 180.

NAL Call Number: 47.8 Am33P

Descriptors: hens, food deprivation, egg production, specific gravity

Gonzalez EA (1970). **Aspectos economicos de la muda forzada engallinas ponedoras. [Economic aspects of forced moulting in laying hens.]** *Ciencia Veterinaria (Mexico)* 15(1): 55-63.

NAL Call Number: 41.8 C483

Gordon RW; Roland DA Sr (1997). **Performance and profitability of second cycle laying hens as influenced by body weight and body weight reduction during molt.** *Poultry Science* 76(Suppl.1): 3.

Dep. Poult. Sci., Auburn Univ., Auburn, Alabama

NAL Call Number: 47.8 Am33P

Descriptors: body weight, economics, egg weight, feed consumption, feed costs, molt, performance, profit

Horn RG (1976). **A look at force moulting [Economics of poultry production]** *Poultry Notes New South Wales Department of Agriculture* Jan: 9-18.

NAL Call Number: 47.9 N472

Kashibuchi M (1972). **Forced molting in laying chicken and its economic traits in poultry industry.** *Animal Husbandry (Tokyo)* 26 (12): 68-72.

NAL Call Number: 49 C43

Kashiwagi S; Shirasaki K; Sagara H; Kaizuka T; Nakaso H; Iwase N; Yamao H; Takahashi Y; Matuzaki M; Ikeda K; Okuyama M (1981). **Effects of restricted feeding during the rearing period and of induced molting during the laying period on the economical profit in the laying hens.** *Japanese Poultry Science* 18(2): 105-119.

Kagoshima Prefectural Poultry Experiment Station, Sendai-shi 895, Japan.

NAL Call Number: 47.8 N57

From the results of previous research (see previous abst.) a management programme was recommended in which growing pullets were given restricted feed. From an economic analysis it is recommended that hens should be force-moulted at 80 weeks and replaced at 113 weeks of age. With the recommended feeding programme it is concluded that the economically-productive life of a hen will be increased by 40% and that the annual profit per hen will be increased by up to 26%, compared with hens fed to appetite without force-moulting.

Descriptors: feed intake, hens, moulting, egg production

Lee K; Holiday OR; Petty CE (1981). **Effect of force molting regime on economic return (chickens, egg production).** *Arkansas farm research - Arkansas Agricultural Experiment Station* 30(2): 11.

NAL Call Number: 100 AR42F

McClelland JW; Wetzstein ME; Noles RK (1989). **Dynamic asset replacement decisions to enhance farm profits.** *Technical Bulletin, US Department of Agriculture* No. 1758, 24pp.

NAL Call Number: 1 Ag84Te no.1758

A model is developed to improve farm profitability by helping farmers determine when to rejuvenate assets instead of replacing them. The model is especially applicable to recyclable assets (like breeding stock, producing stock, farm machinery) and when replacement costs are a significant portion of production costs. In making its rejuvenation/replacement recommendation, the model considers seasonal fluctuations in net revenue resulting from price cycles of the farm product. Applied to the Georgia egg industry, the model shows that force molting hens (temporarily halting egg production) can extend their productive life. A

mixed strategy of asset rejuvenation and replacement can raise profits significantly.
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McDaniel BA; Aske DR (2000). **Egg prices, feed costs, and the decision to molt.** *Poultry Science* 79(9): 1242-1245.

NAL Call Number: 47.8 Am33P

On April 7, 1998, the United Poultry Concerns filed a petition with the Department of Health and Human Services of the Food and Drug Administration calling for the elimination of the practice of forced molting of laying hens in the US. In reaction to this petition, this study investigated the economic importance of forced molting as a short-term production management tool for egg producers. The relationship between shell egg prices and feed costs and the occurrence of forced molting in the five shell egg-pricing regions in the US was addressed. The purpose of this analysis was to determine whether forced molting is used to slow egg production during periods of falling or low egg prices or periods of high or rising feed costs. Ordinary least squares was used to test the relationship between the independent variables (egg, corn, and meal prices) and the dependent variable (percentage of layers in molt). In four of the five regions, there was a significant inverse relationship ($P < 0.05$) between egg prices and the percentage of layers in molt. This analysis suggests that producers were influenced by current egg prices when making the decision to molt. However, the relationship between the percentage of layers in molt and corn and meal prices was less clear. Although a positive relationship between feed prices and molt was found in each region, in only one region was the relationship statistically significant ($P < 0.05$).

Descriptors: hens, molting, egg production, agricultural prices, price elasticities, production costs, maize, soybean oilmeal

Narahari D (2001). **Performance of force-moulted hens.** *Cheiron* 30(5/6): 153-156.

Department of Poultry Science, Madras Veterinary College, Chennai - 600 007, India.

NAL Call Number: SF604 C56

The effects of force-moulting on the subsequent performance of hens and on the cost of production of eggs were studied. A total of 52 989 commercial hybrid hens were used in this study. Force-moulting of hybrid layers, by combining feed, water and light restriction at 75 weeks of age, increased egg production by 14.8%. The 13-month pre-moult hen-day egg production was 79.9%, whereas the 6-month post-moult hen-day egg production was 76.1%. The post-moult peak egg production was 84.7%. The mortality during pre-moult, moulting and post-moult periods were 10.8, 3.12 and 5.26%, respectively. The total cost of egg production was Rs 1.12 during pre-moult; whereas, the post-moult egg production cost was Rs 1.00 only, leading to a 10.7% reduction in the egg production cost. When pre- and post-moult egg production periods were combined (20-106 weeks), the egg production cost was Rs 1.08, with a saving of 3.57%. Based on this study, it is more economical to retain layers for egg production, until 106 weeks of age after force-moulting at around 75 weeks of age.

Descriptors: costs, egg production, eggs, hens, laying performance, mortality, moulting, poultry

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Parlour JW; Halter AN (1970). **A study of the economics of force molting in commercial egg production.** *Oregon Agricultural Experiment Station Technical Bulletin* 112, Dec 1970, 74pp.

NAL Call Number: 100 OR3S

Descriptors: decision theory, economic analysis, eggs, risk, management, poultry, t-linear programming

Sahota AW; Bhatti BM (2001). **Effect of feed restriction during growing period on laying performance of white leghorn hens.** *Pakistan Veterinary Journal* 21(3): 145-147.

Poultry Research Institute, Punjab, Shamsabad Murree Road, Rawalpind, Pakistan

NAL Call Number: SF604 P32

The experiment was conducted to study effect of feed restriction during growing period on the subsequent performance of commercial White Leghorn (Babcock) layers. Two hundred and seventy chicks (6-weeks-old) were randomly divided into three equal groups (A, B and C). The birds in group A were given feed ad libitum (full feeding -FF) while those in groups B and C maintained on the restricted feeding (RF) were given 10 and 20 % less feed than the recommended daily feed allowance, respectively from 7 to 9 and 13 to 15 weeks and 20 and 30 percent lesser feed respectively, of the daily allowance from 10 to 12 weeks of age. From 16 weeks onward till 58 weeks of age all the groups were fed ad libitum. The results showed reduction ($P < 0.01$) in feed intake and body weight ($P < 0.05$) of pullets and delay in age of sexual maturity ($P < 0.01$) due to feed restriction. During the laying phase a non-significant effect of the feed restriction programme on egg production, feed consumption, feed conversion efficiency (feed/dozen eggs), mortality rate and cost of feed/dozen eggs was noted. An overall benefit of Rs. 13.54 and 21.54 on RF-I (group B) and RF-II (group C), respectively, in comparison to that of FF during the growing period reflect on better economics of feed restriction programme in laying stock under given environmental conditions.

Descriptors: age at first egg, costs, feed conversion efficiency, feed intake, hens, laying performance, liveweight, mortality, poultry, pullets, restricted feeding, sexual maturity
Copyright© 2002, CAB International

Sharma RR; Mehta RK (1998). **Economics of feeding different levels of protein to force moulted commercial White Leghorn egg laying hens.** *Indian Journal of Animal Production and Management* 12(3/4): 154-158.

Department of Animal Nutrition and Forages, Punjab Agricultural University, Ludhiana 141004, India

NAL Call Number: SF55 I4I53

Experiments were conducted to develop a cost-effective post-moult feeding programme for hens. 57-week-old commercial White Leghorn hens were force-moulted, divided into 3 groups and fed on diets containing 13 (T1), 15 (T2) or 17% (T3) CP for 32 weeks. Diets contained maize, deoiled rice bran, deoiled groundnut cake and fish meal. Economics of egg production in the second year was compared with that in the first year (pre-moult). Egg production was 58.3, 63.6 and 63.9% in T1, T2 and T3, respectively; egg size was 53.0, 55.5

and 56.7 g, respectively. Feed intake per egg laid was 207, 187 and 189 g, respectively. Based on egg production and egg mass, feed cost/egg was lowest in T2. Cost of moulting, which took into account salvage value, feeding cost during moulting, labour and amortization cost, was Rs 36.32, 38.98 and 39.44 for T1, T2 and T3, respectively. Profit/hen for 32 weeks was greater during the second year; profit/head and moulting profit/head were highest in T2 (Rs 7.93 vs. 2.14 and 4.18 in T2 and T3, respectively). The results suggest that under the conditions of the present study, maximum profit can be achieved by feeding force-moulted hens 15% CP.

Descriptors: hens, feeding, costs, egg weight, feed intake, protein intake, economics, egg production, poultry

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Shirasaki K; Kashiwagi S (1987). **Effects of restricted feeding during the rearing period and of induced molting during the laying period on the economical profit in the laying hens.**

Japanese Poultry Science 24(6): 336-347.

Kagoshima Prefectural Poultry Experiment Station, Sendai-shi 895, Japan

NAL Call Number: 47.8 N57

Equations are given for computing profits with laying hens fed freely or subjected to feed restriction and force-moulted at 56, 68, 80 or 96 weeks old or at 56 and 96, or 68 and 96 weeks old.

Descriptors: egg production, feed intake, economics moult

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Smith GS (1990). **A stochastic asset replacement model for regenerative assets.** *Dissertation Abstracts International. A, Humanities and Social Sciences* 50(10): 3309.

Thesis, University of Georgia, 1989, 112pp., available from University Microfilms, Inc.

Order Number: DA9007699

NAL Call Number: Z5055.U49D5

A dynamic stochastic replacement model for regenerative assets is developed. Numerical techniques are implemented in estimating the theoretical model for a layer hen application. The cyclical nature of egg prices is exploited in solving an infinite horizon problem with dynamic programming procedures. Layer hens and the moulting process are considered regenerative in nature. Production prices and quantities are stochastic elements in the objective functional. Parameterization of risk parameters indicates varying levels of force moulting decisions as well as optimal lengths of production periods. As risk aversion increases (decreases) decisions to molt a flock, versus straight replacement, increases (decreases). Sensitivity of the model to stochastic elements of the objective functional is also explored. Initial solutions, given expectations of prices and quantities, were found to be fairly robust to random shocks to prices and quantities.

Descriptors: risk, eggs, prices, moulting, poultry farming, hens, replacement, optimization, stochastic models, dynamic programming, optimization methods

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Swanson MH; Bell DD (1976). **Force molting of chickens. VI. Economics [Costs].** *Division of Agricultural Science, Univ Calif Berkeley Coop Ext Leaflet Number 2874*: 11pp.
NAL Call Number: S544.3.C2C3

Zeddies J (1981). **Economical aspects for inducing force moulting in layers.**
[Betriebswirtschaftliche Betrachtungen zur Durchführung der Mauser bei Legehennen.]
Archiv für Geflügelkunde 45(4): 158-166.
NAL Call Number: 47.8 AR2
Descriptors: hens, egg production, economics, cost benefit analysis, molting

Zeelen HHM (1975). **Technical and economic results from forced moulting of laying hens [Egg production costs].** *Worlds Poultry Science Journal* 31(1): 57-67.
NAL Call Number: 47.8 W89

Zeelen HHM (1973). **Technical and economical results of forced moult in layers. [Technische en economische resultaten met geforceerde rui bij leghennen.]** *Bedrijfsontwikkeling* 4(7/8): 681-685.
NAL Call Number: S11.B43
25,000 layers were involved in a series of tests on four farms over several years. In one test, production was compared in hens brought into moult during the 10th four-week laying period and in untreated controls. Results were converted to a yearly basis. In the two groups respectively, the number of eggs produced/hen averaged 211.8 and 214.8, egg weight 62.6 and 61.6 g., weight of eggs produced/hen 13.25 and 13.26 kg., and food consumed/kg. eggs produced 3.09 and 3.07 kg. A similar test involved hens brought into moult in the 10th, 11th or 12th four-week period and controls. The number of eggs produced/hen averaged 220.7, 221.4, 222.0 and 226.7 respectively, egg weight 63.2, 63.1, 63.3 and 62.2 g., weight of eggs produced/hen 13.94, 13.96, 14.05 and 14.10 kg., and food consumed/kg. eggs produced, 2.93, 2.92, 2.95 and 2.88 kg.
Descriptors: hens, moulting, induction, laying performance, egg production, egg weight, food conversion
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Selected Websites

Economics of Alternative Replacement Programs - An Egg Economics Update Number 226 - April 20, 2000, Cooperative Extension - University of California at Davis
<http://animalscience.ucdavis.edu/Avian/eeuAPR00.htm>

Is your current replacement program still the best? An Egg Economics Update Number 178 - April 19, 1996, Cooperative Extension - University of California at Davis
<http://animalscience.ucdavis.edu/Avian/eeu496.pdf>

NUTRITIONAL AND LIGHTING MANIPULATIONS

Agcanas PB (1971). **Observation on the effect of forced-molting of single combed White Leghorn hens due to an abrupt change of feeds.** *Philippine Journal of Animal Industry* 28(1/4): 15-18.
NAL Call Number: 49.9 P53P

Ahmed N; Zia-ur-Rahman; Akram M; Shah TH; Yousaf M (1995). **Effect of a new molting program on productive performance of spent layers under indigenous conditions.** *Pakistan Veterinary Journal* 15(1): 46-48
Department of Poultry Science, University of Agriculture, Faisalabad-38040, Pakistan
NAL Call Number: SF604 P32

During the 1st week of Dec., 288 Babcock commercial layers were subjected to a newly developed molting schedule. The fowls had completed their 1st production cycle at 76 weeks of age. The layers were given full feed and 24.5 h light during a premolt period of 3 days, along with treatment for helminths and vaccination for infectious bronchitis and Newcastle disease, and antibiotics during that period. For molting the photoperiod was reduced to 6 h per day for 7 weeks and the birds were subjected to fasting for 1 week accompanied with water deprivation for 3 days. This resulted in body weight reduction by about 27.3% with 1.04% mortality during the 1st week. The average hen-day egg production for the 42-week period was >71% with 89% peak production. The number of eggs laid per hen housed was 207.49 with a marked improvement in egg weight, averaging 63 g.

Descriptors: molting, performance, molt, induction, egg production, tropics

Akram M; Mushtaq-Ul-Hassan M; Farid S; Dar B; Raza NM; Khanum S (2001). **Post-moult body weight and production performance of commercial layers induced to moult under various nutritional regimes.** *Acta Veterinaria* (Beograd) 51(2/3): 163-170.
Department of Poultry Husbandry, University of Agriculture, Faisalabad, Pakistan.
NAL Call Number: 41.8 V6447

The experiment was carried out on 288 commercial (White Leghorn) laying hens available at the age of 71 weeks. Birds were randomly divided into 18 experimental units comprising of 16 birds each. These experimental units were randomly allotted to 6 treatment groups designated as A, B, C, D, E, and F with 3 replications each. All groups were given a pre-moult treatment of vaccination and medication prior to subjecting them to the moulting schedule. Group A was maintained as a control. During the post-moult period, each bird was offered 110 g/day layer mash. Post-moult hen-day production (%), egg mass and feed efficiency (per kg egg mass basis) varied significantly between moulted and non-moulted birds. Less body weight was gained by the birds which were served with restricted feed (1.71

plus or minus 0.11) and corn (1.74 plus or minus 0.15) during the molt. The highest hen-day production (%) (82.87 plus or minus 6.89) and greatest feed efficiency (either per dozen eggs; 1.52 plus or minus 0.13 or per kg egg mass; 2.02 plus or minus 0.22) were noted in the birds which were fed with corn during the moult. Maximum egg weight (65.38 plus or minus 6.18) and feed consumption (743.24 plus or minus 30.50) were recorded in the birds offered with ration No. 3 during the moult.

Descriptors: body weight, egg mass, egg production, eggs, feed conversion, feed intake, feeding, hens, maize, moult, moulting, poultry

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Bai Y; Sunde ML; Cook ME (1994). **Egg production of laying hens before and after force-molting is not correlated.** *The Journal of Applied Poultry Research* 3(2): 127-132. University of Wisconsin, Madison, WI.

NAL Call Number: SF481.J68

Descriptors: hens, laying performance, molting, fasting, restricted feeding, refeeding, duration, oats, hen feeding, selection criteria

Baker M; Brake J (1981). **Relationship of body weight loss during a forced molt of commercial layers to optimum postmolt performance.** *Highlights of agricultural research - Alabama, Agricultural Experiment Station* 28(2): 16.

NAL Call Number: 100 AL1H

Baker M; Brake J; McDaniel GR (1983). **The relationship between body weight loss during an induced molt and postmolt egg production, egg weight, and shell quality in caged layers.** *Poultry Science* 62(3): 409-413.

NAL Call Number: 47.8 Am33P

Two trials were conducted to determine the relationship between percent body weight loss (% BWL) during an induced molt and postmolt performance. The molt was induced by fasting and photoperiod manipulation. Four groups with 24, 27, 31, or 35% BWL (Trial 1) or 20, 25, 30, or 35% BWL (Trial 2) were utilized in each trial. Performance was evaluated on the basis of 24 weeks of egg production and determinations of egg weight (EW), specific gravity (SG), and shell weight (SW) conducted during Weeks 8 (Trial 2 only), 18, and 24 following the removal of feed. The 27 and 31% BWL groups of Trial 1 and the 30 and 35% BWL groups of Trial 2 produced significantly more eggs per hen housed than the remaining treatments in their respective trial. Differences in SG and SW at the end of the trial were most pronounced in Trial 1 where the 27 and 21% BWL groups exhibited significantly greater SG and SW at Week 24 than did the 24 or 35% BWL groups. No significant differences occurred for SG at Week 24 of Trial 2, but the 35% BWL group exhibited significantly improved SW when compared to the 25% BWL group with the remaining groups intermediate. The EW was greatest for the 31% BWL and least for the 35% BWL group at 24 weeks in Trial 1 but did not differ in Trial 2. It was concluded that a body weight loss of approximately 27 to 31% produced optimum postmolt performance.

Descriptors: *Body Weight; *Chickens--physiology--PH; *Oviposition; Egg Shell; Eggs; Housing, Animal

Baloch WA; Suzuki H; Onoue Y (2000). **Effect of different fasting and feeding regimes on body weight and productive performance of layers after first induced molt.** *Pakistan Journal of Zoology* 32(3): 275-277.

Department of Freshwater Biology and Fisheries, University of Sindh, Jamshoro, Pakistan
NAL Call Number: QL1 P3

One hundred and eighty commercial (Babcock) hens, 108 weeks old, after the completion of the first production cycle were kept in 18 experimental units comprising ten birds each. The 18 experimental units were randomly assigned to 6 treatment groups comprising 3 starvation X 2 feeding regimes in a factorial arrangement with 3 replicates. Groups A, B and C were starved for five, ten and 15 days, respectively. Two feeding regimes, feeding daily (groups AD, BD and CD) and on alternate days (groups AE, BE and CE) were carried out for ten days following each starvation regime. The results showed that the group of birds starved for 15 days with alternate day feeding maintained relatively less mean weight (1.51 kg) leading to significantly higher weekly egg number (4.82), egg mass (290.30 g), hen-day production (68.88), and better feed efficiency in terms of feed intake per dozen eggs (1.98) and per kg egg mass (2.75). However, egg weight showed no significant differences in relation to starvation or feeding regime.

Descriptors: body weight, egg production, egg weight, feed conversion efficiency, feed intake, feeding, feeding frequency, fowl feeding, management, poultry, starvation

Bar A; Razaphkovsky V; Wax E; Malka Y (2001). **Effect of age at molting on postmolting performance.** *Poultry Science* 80(7): 874-878.

Institute of Animal Science, Agricultural Research Organization, the Volcani Center, Bet Dagan, Israel. ariebar@agri.gov.il

NAL Call Number: 47.8 Am33P

Molt was induced at the 431, 501, or 571 d, in Lohmann (L) and Hy-Line W-77 (H) hens, by 8 or 14 d, respectively, of feed withdrawal followed by a rest period of 16 d. Induced molt resulted in increases in egg production, numbers of intact eggs, egg mass per housed or surviving hen, and shell quality and in decreases in egg breakage (not significant), mortality, and culling. Egg weight was only slightly affected by molt, and the EW of hens induced to molt at 431 or 501 d of age were slightly lower than those of the unmolted hens or of those induced to molt at 571 d. Both strains reacted similarly to molt, although the L hens responded better, and expressed their responses more intensively when induced to molt earlier (431 d). This finding suggests that although different breeds have some effects of molt in common, molt protocols should be finely tuned for each breed. Total intact egg production and egg mass of the molted hens became higher than those of the unmolted hens at 650 to 728 d, which suggests that no benefit would be achieved by rearing molted hens for less than 700 to 730 d.

Descriptors: hens, molting, age, performance, age differences, feed rations, food restriction, egg production, fecundity, egg shell quality, mortality, culling, egg weight, egg mass

- Bell D; Kunev D (1984). **A comparison of force molting methods. IV. Progress in Poultry "Through Research."** June (27): 6 p.
University of California: Cooperative Extension, University of California.
NAL Call Number: SF487.8.C2P76
Descriptors: hens, molting, strain differences
- Bell D; Kunev D (1979). **A comparison of force molting methods. II. Progress in Poultry "Through Research."** Feb (15): 11 p.
University of California : Cooperative Extension, University of California.
NAL Call Number: SF487.8.C2P76
Descriptors: hens, molting, laying performance, diet
- Bell D; Swanson M; Kunev D (1980). **A comparison of force molting methods. III Progress in Poultry "Through Research."** May (21): 6 p.
University of California: Cooperative Extension, University of California.
NAL Call Number: SF487.8.C2P76
Descriptors: hens, molting, laying performance
- Bell D (1991). **Ten versus fourteen day fasting with and without molt feed. Poultry Adviser** 24(12): 59-61.
University of California, Riverside, USA.
NAL Call Number: SF481 P622
White Leghorns of 6 different strains were fed in 4, 28- to 40-week experiments of 10 or 14-days starvation followed by 18 days of diets containing cracked milo (sorghum) or fed immediately on mash diets. Body weight was decreased by 24.5 and 28.8% with 10 and 14 days starvation, respectively. 14 days starvation and 18 days of milo feeding gave the highest hen day egg production (60.9%), increased feed conversion efficiency, decreased mortality and gave favourable shell smoothness and thickness compared to the other treatments.
- Bessarabov BF; Zhavoronkova LD; Kuznetsov VS; Gorbachev EP (1973). **The use of artificial moulting in commercial poultry production. [Ispol'zovanie metoda iskusstvennoi lin'ki kur v promyshlennom ptitsevodstve.] Sbornik Nauchnykh Trudov. Moskovskaya Veterinarnaya Akademiya No. 71: 131-132.**
In a flock of 6000 Katman-63 White Leghorns, aged 552 days, moulting was induced by 3 days of starvation and withholding of water, followed by gradual re-introduction of normal feeding, and restriction of light to 8 h/day, followed after 1 mth by an increase of ½ h light daily until the daily photoperiod reached 16 h. Laying had ceased entirely 5 days after the beginning of starvation, and started again on the 20th day. 50% egg production was reached on day 60. At 620 days of age, egg production percentage was 62 v 30 prior to the moult. Egg weight at 620 days of age in moulted birds was 11.2% greater than that of 16-mth-old, unmoulted birds.
Descriptors: moult, induction, egg production, egg weight
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Brake J; Thaxton P; Garlich J D; Sherwood DH (1979). **Comparison of fortified ground corn and pullet grower feeding regimes during a forced molt on subsequent layer performance.** *Poultry Science* 58(4): 785-790.

Poultry Science Dep., North Carolina State Univ., Raleigh, NC 27650, USA.

NAL Call Number: 47.8 Am33P

The 160 Hyline W-36 and 3000 Shaver 288 Single-Comb White Leghorn hens were force-molted. Then for 18 days they received ground maize fortified with minerals and vitamins or growing feed for pullets. Performance was measured during the molt and for 5 or 6 periods of 28 days afterwards. Hens given the growing feed began to lay earlier than hens given maize, and reached peak production 4 weeks earlier. They produced more eggs of the same size and shell quality, with better feed utilization and mortality rate than the group given maize. 17 ref.

Descriptors: hen feeding, complete feeds

Buhr RJ; Cunningham DL (1994). **Evaluation of molt induction to body weight loss of fifteen, twenty, or twenty-five percent by feed removal, daily limited, or alternate-day feeding of a molt feed.** *Poultry Science* 73(10): 1499-1510.

Department of Poultry Science, University of Georgia, Athens, GA.

NAL Call Number: 47.8 Am33P

Postmolt egg production variables were compared among hens induced into molt by feed removal, by limited daily feeding of a low-density and low-energy molt feed at 22.8 g per hen, or by limited alternate-day feeding at 45.5 g per hen, until approximate body weight loss of 15, 20, and 25% was obtained. Hens were housed two per cage (25.4 x 45.7 cm) in a house of environmental design, and photoperiod was reduced to 8 h during the 28-d molt period. When target body weight loss was obtained, packed cell volume was determined and hens were maintained on 45.5 g/d of 1.2% calcium prelay feed through the 28-d molt period. Egg production and mortality were recorded daily; egg weight, egg specific gravity, body weight, and feed intake were recorded at 4-wk intervals postmolt. Packed cell volume of hens molted by feed removal (36.4%) was higher ($P < .01$) than that of alternate-day (34.1%) or daily limited (33.6%) hens. Hens that lost 25% of their body weight had higher packed cell volume (36.3%) than hens that had body weight loss of 20% (34.4%) or hens that lost 15% (33.4%). Postmolt mortality and egg production were not different ($P > .05$) as a result of molt induction method or percentage body weight loss. At the 4th wk postmolt, body weights were 50 and 57 g heavier for hens that had lost 15% body weight than those that lost 25 or 20%, respectively, and egg production was negatively linearly related to body weight loss. From the 8th to the 28th wk postmolt, within 4-wk periods, molt induction method or percentage body weight loss did not affect feed consumption (91.8 to 103.9 g), egg weight (66.0 to 66.2 g), egg specific gravity (1.0823 to 1.0831), or body weight (1,634 to 1,788 g).

Descriptors: hens, molting, weight losses, body weight, hematocrit, egg production, feed intake, fasting, mortality

Camiruaga LM (1977). **El ave de postura. Pro y contra de la pelecha forzada [The laying hen. the pros and cons of forced molting]**. *Journal: Campesino* 108(12): 26-33.

Universidad Catolica de Chile, Santiago

NAL Call Number: 9.3 So12

Castanon F; Leeper RW; Parsons CM (1990). **Evaluation of corn gluten feed in the diets of laying hens**. *Poultry Science* 69(1): 90-97.

University of Illinois at Urbana-Champaign, Urbana, IL

NAL Call Number: 47.8 AM33P

The use of corn gluten feed (CGF) in the diets of laying hens and in induced molting programs was investigated through four experiments. The first two experiments evaluated the effects of CGF on egg production from 23 to 56 or from 32 to 65 wk of age. Graded levels of CGF from 0 to 25% were added to a corn-soybean meal, control diet (16.5% CP) in a nonisocaloric and an isocaloric manner. The ratio for dietary MEn:protein was held constant in some diets, but varied in others. The nonisocaloric inclusion of up to 25% CGF did not negatively affect egg production in either experiment. When 25% CGF was fed to the 32 wk old hens, egg weight was decreased. Egg weight was also decreased when 10% CGF or higher levels were fed to the younger hens. The nonisocaloric addition of CGF also increased feed intake and decreased feed efficiency (gram of egg per gram of feed) in most cases. Isocaloric inclusion of 15% CGF did not affect egg-production parameters, but 25% CGF negatively affected most parameters. When the ratio for MEn:protein of the CGF diets was equal to that of the control diet, 25% CGF negatively affected most parameters, 17.5% CGF decreased egg weight and feed efficiency, and 10% CGF increased egg production. Feed intake was increased at all of the CGF levels. Two additional experiments evaluated CGF in programs for induced molting. The molting procedure involved feed withdrawal for 10 days followed by feeding molt diets consisting of 99.75% corn, 99.75% CGF, 49.75% corn:50% CGF, or two grower-type diets for pullets (15% CP) containing 25% CGF or 18.5% wheat bran. The two grower-type diets for pullets yielded similar and significantly greater postmolt gains in body weight and early postmolt egg production (3 wk) than did the other diets. The corn:CGF diet also yielded greater postmolt weight gains and early postmolt egg production than the 100% corn or 100% CGF diets. Long-term postmolt egg production (30 or 37 wk) was not affected by the molt diets.

Descriptors: *Animal Feed; *Animal Nutrition; *Chickens--physiology--PH;

*Gluten--administration and dosage--AD ; Chickens--growth and development--GD; Corn; Oviposition

Cave NAG (1983). **Effect of duration of induced-molting period on broiler breeder hens**.

Poultry Science 62(7): 1398.

Agriculture Canada, Centre for Animal Research, Ottawa KLA 0C6, Ontario, Canada

NAL Call Number: 47.8 Am33P

Christmas RB (1987). **Short rests versus long molt of laying hens**. *Proceedings of the ... Florida Poultry Institute* (46th): 42-52.

University of Florida, Chipley, FL

NAL Call Number: SF481.2.F56

Descriptors: hens, eggs, egg production, molt, rest, specific gravity, laying performance

Christmas RB (1986). **Recent force resting procedures for laying hens.** *Poultry Adviser* 19(11): 27-34.

Poultry Science Dep., Univ. Florida, Gainesville, FL, USA

NAL Call Number: SF481 P622

Laying hens are force-rested one or more times during their productive life in order to improve egg-shell quality, egg production and cash flow. Force-resting includes starvation for 7 to 10 days with or without water for 1 day. Starvation is followed by feeding on a low-protein, low-calcium diet until egg production is resumed. Literature on force-resting of layers is reviewed.

Descriptors: egg shell quality; egg production, force resting

Christmas RB; Harms RH (1984). **The subsequent performance of hens subjected to standard or short 4 day force rest methods.** *Poultry Science* 63(SUPPL. 1): 79-80.

Dep. Poultry Sci., Univ. Fla., Gainesville, FL 32611.

NAL Call Number: 47.8 Am33P

Christmas RB; Harms RH (1983). **The performance of four strains of laying hens subjected to various postrest combinations of calcium and phosphorus after forced rest in winter or summer.** *Poultry Science* 62(9): 1816-1822.

NAL Call Number: 47.8 AM33P

Four strains of laying hens, including one brown egg strain, were force-rested in February at approximately 62 weeks of age. Hens from the same four strains, which were the same age, were also force-tested under similar conditions during August of the same year. In each of the two trials, a total of 2300 hens were housed at the rate of two per 25.4 x 45.7-cm cage. The resting procedure for both studies included feed withdrawal for 9 or 10 days followed by feeding a 8.6% protein diet for 25 days. Water was supplied at all times. After the 35-day resting period, the hens were assigned to four calcium and phosphorus combinations, which varied from the duplication of a first-year pullet phase feeding program to the feeding of a final phase type diet for the entire postrest production period. Nutrient level within each dietary system was adjusted periodically based on daily feed intake. Strain performance differences were observed in both seasons. Rate of return to production and postrest production rates were similar to the patterns observed within the respective strain's performance during the pullet year. This was noted in both studies. Relative strain production performance, however, when compared to the other strains, was not consistent between the two rest seasons. There was no difference in performance due to calcium and phosphorus treatment utilized in either postrest production season.

Descriptors: *Calcium Phosphates--administration and dosage--AD; *Calcium, Dietary --administration and dosage--AD; *Chickens--physiology--PH; *Oviposition ; Body Weight; Chickens--genetics--GE; Seasons

CAS Registry No.: 0 (Calcium, Dietary); 10103-46-5 (calcium phosphate)

- Christmas RB; Harms RH (1983). **The effect of protein level during force-rest recovery on the performance of winter or spring rested laying hens.** *Poultry Science* 62(7): 1403.
University of Florida, Dept of Poultry Science, Gainesville, Florida 32611
NAL Call Number: 47.8 AM33P
- Christmas RB; Harms RH (1983). **Performance of laying hens subjected to various nutritional systems after force-rest in the winter or summer.** *Poultry Science* 62 (7): 1402.
University of Florida, Dept of Poultry Science, Gainesville, Florida 32611
NAL Call Number: 47.8 AM33P
- Christmas RB; Harms RH (1983). **Subsequent post-rest performance of laying hens as affected by water restriction at 2 different times during the force rest period.** *Poultry Science* 62(7): 1341.
University of Florida, Dept of Poultry Science, Gainesville, Florida 32611
NAL Call Number: 47.8 AM33P
- Christmas RB; Harms RH (1983). **The postrest performance of laying hens subjected to early or late water restriction during the feed withdrawal period (Force-rest).** *Poultry Science* 62(12): 2489-2491.
NAL Call Number: 47.8 AM33P
- Christmas RB; Harms RH (1983). **The performance of four strains of laying hens subjected to various postrest combinations of calcium and phosphorous after forced rest in winter or summer (Metabolism and nutrition).** *Poultry Science* 62(9): 1816-1822.
NAL Call Number: 47.8 AM33P
- Christmas RB; Harms RH (1982). **The effect of various post molt nutritional systems on the performance of 4 strains of laying hens force molted in the winter or the summer.** *Poultry Science* 61(7): 1438.
Univ. Florida, Dep. Poultry Sci., Gainesville, Florida
NAL Call Number: 47.8 AM33P
Descriptors: protein, diet, feed withdrawal, egg production
- Christmas RB; Harms RH; Junqueira OM (1985). **Performance of Single Comb White Leghorn hens subjected to 4 or 10-day feed withdrawal force rest procedures.** *Poultry Science* 64(12): 2321-2324.
NAL Call Number: 47.8 AM33P
Descriptors: hens, laying performance, molting, egg shell quality, rest, fasting
- Christmas RB; Harms RH; Junqueira OM (1985). **Performance of Single Comb White Leghorn hens subjected to 4 or 10-day feed withdrawal force rest procedures.** *Poultry Science* 64(12): 2321-2324.

NAL Call Number: 47.8 AM33P

Descriptors: hens, laying performance, molting, egg shell quality, rest, fasting

El-Beeli MYM; El-Zubeir EA (1991). **Feeding whole-grain sorghum (*Feteraitea*) as a resting agent in egg-type breeder hens.** *Sudan Journal of Animal Production* 4(2): 121-131.

Institute of Animal Production, University of Khartoum, Khartoum North, Sudan.

Use of whole-grain sorghum to induce molting in egg-type breeder hens and whether forced molting techniques would have beneficial effects on reproductive performance were studied. Hens in 5 groups were fed on a control diet of ground sorghum 600, wheat bran 160, sesame meal 50, groundnut meal 50, fish meal 50, oyster shell 80 and NaCl 5 g/kg, or that diet plus zinc oxide 25 or potassium iodide 6.58 g/kg, or the control diet devoid of oyster shell or made up entirely of whole-grain sorghum. During the first 28 days of the trial, all hens received the control diet, and then for 21 weeks they were fed on each of the 5 group-diets. With the high-Zn, high-iodine, low-calcium and whole-grain sorghum diets, the number of days it took the hens to achieve minimum egg production was 20, 17, 70 and 26 days, respectively, and average daily feed intake was 59.1, 84.4, 58.9 and 90.0 g. During the 2nd phase of laying from 73 to 97 weeks old, percentage hen-day egg yield was 48.2, 38.5, 41.0, 47.8 and 38.4, in the 5-group order. Percentage mortality was 8.3, 15.9, 8.0, 8.0 and 9.4. There were no significant differences between groups in mean egg weight or Haugh units. Egg shell thickness was 0.048, 0.054, 0.052, 0.0511 and 0.053 cm; percentage egg fertility, 66.5, 74.3, 60.1, 56.9 and 81.6; and percentage hatchability, 71.7, 70.8, 60.3, 63.9 and 61.5. It was concluded that whole-grain sorghum can be used successfully to induce molting in egg-type breeder hens.

Descriptors: hen feeding, molting, egg fertility, egg hatchability, zinc, iodine, supplements, hens

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Embleton H; Hinds H B (1941). **Poultry feeding experiments / by H. Embleton; Molting and housing experiments / by H.B. Hinds.** *Bulletin / University of Arizona, College of Agriculture, Agricultural Experiment Station* no. 177: 331-365.

University of Arizona Agricultural Experiment Station Tucson, Ariz. : University of Arizona
NAL Call Number: 100 Ar4 no.177

Descriptors: poultry, Arizona, feeding and feeds, feed utilization efficiency, housing, molting

Emeash HH; Attia MZ (1998). **Performance and behavioural characters of layers as influenced by forced molt.** *Proceedings of the Fifth conference of the Egyptian Veterinary Poultry Association*, p. 217-233

Cairo Univ., Beni-Suef (Egypt). Faculty of Veterinary Medicine)

Descriptors in English: layer chickens, forced molting, laying performance, blood composition, age, cages, egg production, behaviour, animal housing, animal husbandry methods, animal performance, animal production, birds, blood, chickens, domestic animals, galliformes, livestock, poultry, production

Escalante Cruz RE; Herrera Crespo JA; Lozano Torres MN; Oliveros Carballosa OO (1993).

Evaluation of two systems of induced molting in commercial White Leghorn laying hens. [Evaluacion de dos sistemas de muda forzada en la ponedora comercial Leghorn blanca.] *Revista de Produccion Animal, Cuba* 7(3): 105-108.

Combinado Avicola Nacional, Camaguey, Cuba.

32,512 hens were deprived of water for 3 days and of food for 7 days (group 1), and 70,500 hens were deprived of water for 3 days and of food for 10 days (group 2). After treatment, the egg production was 50.6 and 50.3% respectively for hens in the 2 groups, egg production per hen averaged 157.2 and 153.6 respectively, food intake per kg eggs 2.32 and 2.44 kg, and the percentage of normal eggs was 96.1 and 96.0. All differences between groups were non-significant, but the 10-day fast produced a significant saving in feeding costs compared with the 7-day fast. Mortality was <2% in both groups.

Descriptors: hens, profitability, restricted feeding, molting, induction, egg production, feed conversion efficiency, mortality, tropics, laying performance

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Farran MT; Dakessian PB; Darwish AH; Uwayjan MG; Dbouk HK; Sleiman FT; Ashkarian VM (2001). **Performance of broilers and production and egg quality parameters of laying hens fed 60% raw or treated common vetch (*Vicia sativa*) seeds.** *Poultry Science* 80(2): 203-208.

NAL Call Number: 47.8 Am33P

Two experiments were conducted to study the effect of feeding 60% untreated (U) or coarsely ground treated vetch (V) seeds on performance of broilers and laying hens. In Experiment 1, the V seeds were soaked in 1% NaHCO₃ (1:10) or in 1% acetic acid (1:5) at room temperature for 24 h (RTAA). Birds on the NaHCO₃-treated V diet had 100% mortality rate but had significantly longer survival time than those on UV (14.9 vs 5.1 d). Birds on RTAA-V survived and had similar BW and feed conversion but greater kidney size than those of the controls at 7 wk of age ($P < 0.05$). In Experiment 2, control, UV, V soaked in water at 40 C (40WV), RTAA-V, and V soaked in acetic acid at 40 C (40AAV) diets were fed to laying hens for 84 d. The ground seeds in RTAA-V and 40AAV were soaked in acetic acid (1:10) at room temperature or at 40 C, respectively, for 24 h. For 40WV, the seeds were soaked in water (1:10) at 40 C for 72 h with a water change every 12 h. The UV-fed hens ceased egg production within 14 d and had the highest BW loss and the lowest feed intake among all treatments ($P < 0.05$). The 40WV and 40AAV significantly improved these criteria. Moreover, the RTAA-V resulted in performance comparable to that of the controls. Eggs produced by hens on treated V diets had similar weight but higher Haugh unit score (11 points), thinner shell, and lower yolk color score than those of the controls ($P < 0.05$). Results indicated that RTAA-V at 60% dietary level was not detrimental to broilers and laying hens. Descriptors: broilers, hens, vetch, *vicia sativa*, seeds, chemical treatment, sodium bicarbonate, acetic acid, detoxification, poisoning, mortality, liveweight gain, feeds, feed conversion, dressing percentage, feed intake, molting, laying performance, egg weight, egg quality, egg shell thickness

Fedorchenko NG; Bololepov VI (1978). **Artificial induction of moulting in hens and its use in reducing mortality from disease.** [Kotsenke metodov iskusstvennoi lin'ki kur.] *Veterinariya, Moscow, USSR* (No. 10): 86-87.

Laboratoriya po Bolezni Molodnyaka Zhivotnykh, Ministerstvo Sel'skogo Khozyaistva, Moscow, USSR.

During artificial moult induction by restricted drinking, feeding and lighting regimes (conventional) the main cause of losses was leukosis (40%). With administration of an anabolic, losses were due mainly to diseases of the egg-forming organs (71.5%). With I/m injection of 1-2.5% oily solution of progesterone, losses occurred from leukosis, diseases of the egg-forming organs, hepatitis and visceral gout. Total losses by the three methods were (respectively) 1.7% of 596 birds, 2.25% of 301, and 1.4% of 294 birds. Other losses were due to cannibalism, pneumonia and colibacteriosis (first method) and enteritis (second method). The first method may be included in control measures for leukosis and other diseases in a breeding flock.

Descriptors: progesterone, anabolics, moulting, hens, poultry, moult, induction, mortality, poultry diseases

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Fratila SO; Nedelescu P (1981). **Technique of forced molting in layer hens.** [Contributii la tehnica napirlirii fortate a gainilor ouatoare.] *Revista de Cresterea Animalelor* 31(10): 19-23.

NAL Call Number: 49 P943

Descriptors: hens, feathers, molting

Garcia EA; Mendes AA; Curi PR; Pinto MCL; Silva ABP da; Poiatti ML (1996). **An evaluation of performance and egg quality of semi-heavy laying hens submitted to induced molt and fed low energy rations during different periods.** [Parametros productivos e qualidade dos ovos de poedeiras semipesadas, alimentadas com racao de baixa densidade por diferentes periodos durante a muda forcada.] *Veterinaria e Zootecnia* 8: 75-84.

Departamento de Producao e Exploracao Animal, Faculdade de Medicina Veterinaria e Zootecnia, UNESP, 18618-000, Botucatu, SP, Brazil.

NAL Call Number: SF604 V466

Descriptors: fowl feeding, egg production, performance, egg quality, hens, molting, energy deprivation, feeds, poultry

Garlich JD; Anderson KE; Brake J (1995). **Molt induction by fasting: Effects of vitamin and electrolyte supplementation in the drinking water.** *Poultry Science* 74(Suppl. 1): 190.

Dep. Poultry Science., N.C. State Univ., Raleigh, North Carolina

NAL Call Number: 47.8 AM33P

Descriptors: chickens, hens, erythrocyte biochemistry

Garlich JD; Parkhurst CR (1982). **Increased egg production by calcium supplementation during the initial fasting period of a forced molt (Laying hens).** *Poultry Science* 61(5): 955-961.

NAL Call Number: 47.8 AM33P

Gerry RW (1979). **The effect of forced molting (resting) on the performance of chickens laying brown eggs.** *Bulletin, Life Sciences and Agriculture Experiment Station, University of Maine* May, Bulletin #755, 19 pp.

NAL Call Number: 100-M28S-1

The results of a series of experiments designed to study the effects of periodic forced molting (by withdrawal of feed and/or water and manipulation of the lighting pattern) on the performance of medium-weight hens, (including breeders) laying brown eggs are reported. The study involved 2 types of birds, 2 experiments of 2 trials each, 2 laying years/trial, 2 types of housing (floors and cages) and several replicates of each treatment in each trial. All of the molting techniques reported caused the birds to cease egg production rapidly and did not cause excessive feather loss. The speed at which birds returned to production depended on the treatment received after the molt, but there appeared to be no advantage to prolonging the rest period. Egg production and feed efficiency over 2 years were not consistently improved although some improvement in egg production was usually observed following the molt. This varied from 10% among birds molted after 12 months of lay to no improvement among birds which had been subjected to a third molt after 18 months of lay. Greater mortality occurred during the first year of the 2-year trials and mortality tended to be less among birds which were molted more often. Treatment had little or no effect on egg weights but improved shell thickness in the second experiment. Interior egg quality, measured in Haugh units, improved after nearly every molt. The performance of force-molted breeding hens was similar and fertility and hatchability after recovery from the molt were similar to those from control hens.

Descriptors: egg production, forced molting

Gulyamov KKH; Komilov DK; Chugunkin DN; Akhmadov T (1977). **Productivity, respiratory gas exchange and heat production in hens force-molted by different regimes of starvation and water availability in a hot climate. [Produktivnost' I gazoenergeticheskii obmen u kur-nesushek, podvergnutykh lin-ke pri razlichnom rezhime golodaniya I dostupa k vode v usloviyakh zharkogo klimata.]** *Zhivotnovodstva* 9: 139-148.

Tematicheskii Sbornik Nauchnykh Trudov. Tadzhikskii Nauchno-Issledovatel' skii Institut
NAL Call Number: 49 Z6

In the experiment, groups 1-4, each of 1840 line 18 Katman crossbred fowls weighing, on average, 1272-1548 g before the experiment, were force-molted by withdrawing food for 5, 8, 10 and 12 days resp., after which ad lib. feeding was progressively reintroduced over a 6-day period. Two subgroups of each group were, resp., (a) deprived of water for 3 days at the start of the experiment, and (b) given water ad lib. Egg production traits were recorded for 212 days after starvation. For the 8 subgroups resp. (i.e. 1a, 1b, 2a, 2b, etc.), egg weight averaged 60.1, 60.1, 60.5, 59.5, 59.8, 60.2, 60.9 and 59.9 g v 58.6 for all hens before the forced molt, shape index 1.38, 1.38, 1.40, 1.38, 1.38, 1.38, 1.40 and 1.38 v 1.36, egg sp. gr. 1.081, 1.078, 1.081, 1.081, 1.079, 1.081, 1.079 and 1.082 v 1.068, percentage of albumen in the egg 52.77, 52.33, 51.58, 52.43, 52.49, 53.01, 52.86 and 52.62 v 58.56, percentage of yolk 36.06, 36.33, 36.90, 37.06, 36.36, 36.72, 35.90 and 36.10 v 31.39, shell thickness 327, 329, 336, 341, 336, 334, 337 and 335 v 309 μ , albumen index 0.086, 0.086, 0.085, 0.086, 0.086,

0.086, 0.084 and 0.085 v 0.086, yolk index 0.431, 0.426, 0.428, 0.423, 0.426, 0.426, 0.422 and 0.429 v 0.418, percentage of hens culled 5.5, 5.7, 5.9, 5.6, 5.3, 5.1, 5.4 and 5.7 v 2.3, number of eggs laid during the experiment 84.08, 87.34, 87.80, 91.27, 83.61, 83.52, 89.82 and 97.27, and weight of food consumed/kg eggs laid 4.14, 3.96, 3.90, 3.76, 4.19, 4.01, 3.84 and 3.47 v 6.16 kg.

Descriptors: moult, induction, laying performance, nutrition, food restriction, water deprivation

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Gupta JJ; Singh KS (1987). **Force molting by nutritional manipulation.** *Indian Journal of Poultry Science : Official Journal of the Indian Poultry Science Association.* 22(3): 221-222.

ICAR Research Complex, Bishnupur, Shillong

NAL Call Number: SF481.I5

Descriptors: hen feeding, molting, egg production

Harms RH (1983). **The relationship of molted primaries of commercial layers to first egg after molt.** *Poultry Science* 62(6): 1123-1124.

NAL Call Number: 47.8 AM33P

The number of primary feathers molted was observed when hens were force molted in two separate experiments. The number of days required for the hens to return to production was directly related ($R = .98$, Experiment 2) to the number of primary feathers molted.

Descriptors: *Chickens--physiology--PH; *Oviposition ; Dietary Proteins--administration and dosage--AD; Feathers--physiology--PH

Harms RH (1983). **Influence of protein level in the resting diet upon performance of force rested hens.** *Poultry Science* 62(2): 273-276.

NAL Call Number: 47.8 AM33P

Hassanein EI; Awadallah SA; Ismail EY; Zahran KA (1985). **Induction of forced molting in Isa-Brown layers by continuous food deprivation.** *Alexandria Journal of Veterinary Science* 1(2): 93-102.

Zagazig Univ., Egypt, Faculty of Veterinary Medicine

Descriptors in English: chickens, weight, forced molting, laying performance, feed conversion efficiency, starvation, biological development, birds, digestibility, domestic animals, domesticated birds, feeding, galliformes, livestock, molting, nutritive value, performance, poultry, quality, useful animals

Hembree DJ; Adams AW; Craig JV (1980). **Effects of force-molting by conventional and experimental light restriction methods on performance and agonistic behavior of hens.** *Poultry Science* 59(2): 215-223.

Department of Animal Sciences and Industry, Kansas State University, Manhattan, Kansas

NAL Call Number: 47.8 AM33P

White Leghorn females , aged 68 wk, were subjected to a stress period (no feed and 8-h light

per day for 10 days) followed by a period when they were fed ground corn and given 8-h light per day for 18 days, or were given the same treatment except that the ground corn was supplemented with cystine, glycine, serine and threonine. White Leghorns not subjected to forced molting served as controls. During the molting period, the percentage hen-day production was 4.9 and 56.2 ($P<0.05$) for force-molted and control hens resp. The corresponding percentages during the first 28 days after molting were approx. 24 and 50 ($P<0.05$), and during 140 days after molting they were approx. 57 and 56.2 ($P<0.05$). In a 2nd experiment, White Leghorn females induced to molt by a regime of cracked corn and no light for 10 days produced heavier eggs ($P<0.05$) after molting than hens induced to molt by starvation and 8-h light per day.

Descriptors: molt, induction, laying performance, light, egg production, restriction, molt induction, force molting

Hembree DJ; Adams AW; Craig JV (1978). **Effects of light restriction and amino acid supplementation on performance and agonistic behavior of forced-molted hens.** *Poultry Science* 57(4): 1143-1144.

Dep. Animal Sciences and Industry, Kansas State Univ., Manhattan, KS 66506, USA.

NAL Call Number: 47.8 AM33P

Descriptors: hen feeding, amino acids, egg production, lighting

Herrick RB; Ross E (1986). **Intermittent and low-intensity lighting for force-molted laying hens.** *Research series - Hawaii Agricultural Experiment Station, Hitahr College of Tropical Agriculture and Human Resources*. July, No. 049: 10 p.

Manoa : Hawaii Agricultural Experiment Station.

NAL Call Number: S539.5.R43

Descriptors: hens, molting, lighting, hen feeding, egg production, strain differences

Hill AT; Richards JF (1975). **Effects of limited watering time on the performance of caged pullets and hens.** *Poultry Science* 54(5): 1704-1706.

Research Station, Agriculture Canada, Agassiz, British Columbia, V0M 1A0, Canada.

NAL Call Number: 47.8 AM33P

In 3 trials with a total of 640 pullets and 592 year-old hens, all Leghorns, some had water freely and others were offered it for 5 equally spaced periods daily, each of 25 min. For pullets, water restriction had no significant effect on egg production, feed conversion or mortality. For hens, it improved feed conversion significantly. In the second year of life, total number of eggs rose significantly when water was restricted immediately after the forced moult. Restriction had no effect on egg weight or the proportion of egg white solids or yolk solids.

Descriptors: hens, feed conversion efficiency, egg production, water restriction

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Hurwitz S; Bornstein S; Lev Y (1975). **Some responses of laying hens to induced arrest of egg production.** *Poultry Science* 54(2): 415-22.

NAL Call Number: 47.8 AM33P

Arrest of egg production was induced by forced-molt (artificial light deprivation and feed deprivation for 10 days followed by 20 days of grain only) and by low-calcium regime in one experiment, and by Nicarbazin in another. Post-arrest production and shell quality significantly surpassed the control in the force-molt but not in the low-Ca treatment. At the onset of production, following the pause, egg weight and shell weight per unit of surface area rapidly increased up to the 9-10th egg. In the second trial, feed intake declined in about one week after the arrest in egg production to a non-layer level. During this week, body weight increased. However, despite the increase in feed intake after the onset of production, pre-arrest levels were not obtained even after 11 days, resulting in a loss of body weight. The separation of flock production into its components, rate of production of the layers, and the proportion of layers in the flock, is proposed.

Descriptors: *Chickens--physiology--PH; *Oviposition ; Animal Feed; Body Weight; Calcium, Dietary--administration and dosage--AD; Calcium, Dietary--metabolism--ME; Cereals; Chickens--metabolism--ME; Dietary Proteins--metabolism--ME; Egg Shell; Eggs; Fasting; Light; Nicarbazin--pharmacology--PD; Phosphates--administration and dosage--AD; Phosphates--metabolism--ME

Hurwitz S; Wax E; Nisenbaum Y; Plavnik I (1995). **Responses of laying hens to forced molt procedures of variable length with or without light restriction.** *Poultry Science* 74(11): 1745-1753.

Agricultural Research Organization, Bet Dagan, Israel.

NAL Call Number: 47.8 Am33P

The importance of the length of the rest period and of photoperiod as components of the forced molt procedure was evaluated in 650- and 560-d-old Lohman hens. The procedure included an 8-d feed withdrawal phase and rest periods varying from 0 to 35 d, during which the birds were fed for maintenance only. In the first trial, forced molt was applied with or without omission of artificial illumination. The rest period varied between 2 and 20 d. In the second trial, all treatments included omission of artificial illumination, and a variable rest period between 0 and 35 d. Egg production ceased, after 4 to 5 d of feed withdrawal and resumed 8 to 15 d after the end of the rest period, without any consistent response to its length. Forced molt stimulated egg production rate and diminished its age-dependent rate of decline, reduced the proportion of broken and shell-less eggs, and improved shell quality. Following wide oscillations proportional to the length of the rest period, egg weight stabilized at levels similar to that of the unmolted controls. Feed intake was stimulated by forced molt to levels exceeding those of the control hens. Body weight increased during the postmolt period to levels slightly exceeding those of unmolted controls. Results of one trial show that omission of artificial illumination was essential for the full expression of the molt responses. In the other trial, production rate and shell quality were improved and the percentage of broken eggs was reduced when the length of the rest period was increased. Maximal improvements appears to have been reached with rests periods of 14 to 21 d.

Descriptors: hens, molting, fasting, restricted feeding, duration, laying performance, egg shell quality, body weight, light regime, feed intake, unrestricted feeding, egg weight, egg shell defects, broken eggs

Hurwitz S; Wax E; Nisenbaum Y; Ben-Moshe M; Plavnik I (1998). **The response of laying hens to induced molt as affected by strain and age.** *Poultry Science* 77(1): 22-31.

Agricultural Research Organization, Bet Dagan, Israel.

NAL Call Number: 47.8 Am33P

Molt was induced in 502-d-old Lohmann, Hy-Line W-77, Yafa, and Yarkon strains of laying hens (Experiment 1), and at different ages during the 1st yr of production in the Lohmann strain (Experiment 2). The induced molt treatment included an 8-d feed withdrawal period followed by a 22-d rest period during which the birds received 60 or 70 g/d of a low-nutrient maintenance diet, in both experiments, respectively, and a reduced duration of daylight. In both experiments, induced molt resulted in an increase in postmolt egg production rate and a diminution of the rate of decline of production with age. The first eggs during the postmolt period were smaller than those of the unmolted birds but egg size increased rapidly to control levels. Egg breakage was markedly reduced by induced molt and its rate of increase with age was diminished. Postmolt feed intake was higher than that of the unmolted birds and body weights reached values higher than those of the controls. Those responses were not different among strains but the ranking among the strains in the molted group was similar to that of the unmolted controls, for all production traits. The postmolt rate of production approached that of first cycle peak and was not affected by treatment age. Shell quality as reflected by the percentage of breakage during the postmolt period was similar to that of the unmolted controls approximately 3 to 4 mo earlier

Descriptors: hens, molting, induction, strain differences, laying performance, egg shell quality, age differences, egg weight, body weight, egg shell, weight, egg shell defects, breakage, feed intake

Huyghebaert G; Fontaine G; Groote G de (1977). **Vergelijkende studie van enkele kunstmatige ruimethoden bij W.L.-hennen [Comparative study of different treatments of forced molting in White Leghorn hens].** *Landbouwtijdschrift* 30(4): 957-977.

Rijkscentrum voor Landbouwkundig Onderzoek, Merelbeke, Belgium. Rijksstation voor Kleinveeteelt)

NAL Call Number: 13 L233

Ingram DR; Mather FB (1988). **White Leghorn production parameters as affected by body weight loss and length of rest period during a force molt.** *Nutrition Reports International* 37(5): 901-908.

Dep. Poultry Science, Louisiana Agriculture Experiment Station, Louisiana State Univ. Agricultural Center, Baton Rouge, LA 70803, USA

NAL Call Number: RC620 A1N8

In a 40-week 3 x 3 factorial design experiment 720 65-week-old Shaver 288A White Leghorn hens within 1.5 standard deviation of mean body weight were deprived of feed to achieve weight losses of 10 to 15, 20 to 25 or 30 to 35% and this weight maintained for 1, 3 or 5 weeks by feeding on ground maize every other day. After the treatment period, standard laying rations were given ad libitum. Egg production was recorded daily, egg weight and specific gravity were estimated on 3 days' eggs when egg production after molting reached

50% of premolting rate and once monthly afterwards. All treatments improved egg production over premolt birds, but overall postmolt hen-day egg production was not significantly different among treatments. Specific gravity was affected more by length of rest than weight loss.

Descriptors: egg production, molt

Jan ML (1982). **Effects of force-molting on egg production of White Leghorn under subtropical environment. II. Effects of body weight and feed withdrawal time on egg production of force molted hens.** *T'ai-wan hsu mu shou I hsueh hui hui pao = The Taiwan Journal of Veterinary Medicine and Animal Husbandry* 40 (August): 39-44.
NAL: 49 J822

Junqueira OM; Custodio RWS; Carvalho NP; Ariki J (1979). **Effect of method of forced molting on laying hens. [O efeito de metodos de muda forcada no desempenho de galinhas reprodutoras.]** *Cientifica* 7(Special No.): 119-122.
NAL Call Number: SF604 C55

In 180 laying hens of different strains natural molting was compared with forced molting. Forced molting was induced at the start of natural molting to increase feather loss and completely stop laying. For forced molting there was total restriction of feed for 15 days and of water for 7, then 40 g feed was supplied daily for 4 days, subsequently 80 g daily for 11 days and finally 120 g. Egg weight was not affected significantly by method of molting, but egg production was increased after forced molting.

Descriptors: egg production, forced molting

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Kalayci UM (1990). **Effects of breeding intensity and methods of molting preparations on the performance of light and medium weight laying hens in the second laying season [Auswirkungen der Aufzuchtintensitat und der Methodik der Mausereinleitung auf die Leistungen leichter und mittelschwerer Legehennen in der zweiten Legeperiode.]** *Thesis (doctoral)--Universitat Bonn, Germany, 137 p.*
NAL Call Number: 105.8 B644 1990 [no.26]

Karunajeewa H; Tham SH; Hofmann A; Harris P (1986). **The effects of rice by-products, acidulated soapstock and sunflower seeds on the laying performance of induced moulted hens.** *Archiv fur Geflugelkunde* 50(5): 193-197.
Animal Research Inst., Princes Highway, Werribee, Vic. 3030, Australia
NAL Call Number: 47.8 AR2

From 72 to 92 weeks old a total of 576 induced-moulted White Leghorn hens were in 6 treatment groups. The control diet (B1) was based on wheat and meat-and-bone meal and had linoleic acid 0.69%. In diets B2, B3 and B4 some of the wheat and meat-and-bone meal was replaced by either acidulated soapstock (ASS) rice pollard (RP) or deoiled rice pollard (DRP) to increase the linoleic acid contents in these diets to 1.00, 1.21 and 0.82%, respectively. In diets B5 and B6 mixtures of DRP and ASS (B5) and DRP and sunflower seeds (B6) were

used to increase the linoleic acid content to 1.13 and 1.14%. All 6 diets were formulated to be isonitrogenous and isoenergetic (11.63 MJ/kg). Methionine (0.26%) and lysine (0.69%) in diets were equalized by supplementation with synthetic methionine and L-lysine HCl. Calcium in the diets was equalized to 3.4% but phosphorus varied with the inclusion of RP and DRP. Diets were given in the mash form for 5 periods of 28 days each. Increasing the linoleic acid content from 0.69 to 1.21% had no significant effect on egg weight or other production characteristics (rate of lay, daily feed intake, feed intake/kg eggs, body weight at 92 weeks, mortality). Inclusion of 2.16% ASS containing rapeseed soapstock reduced the proportion of eggs >65 g, and the inclusion of 1.67% whole sunflower seeds reduced the Haugh units (albumen quality) of eggs. The fatty acid composition of egg yolk was affected by the composition of the dietary fats.

Descriptors: rice byproducts, hen feeding, soapstock, sunflower seeds, egg production, nutrition, poultry

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Kashiwagi S; Shirasaki K; Kaizuka T; Nakaso H; Iwase N; Yamao H; Takahashi Y; Matsuzaki M; Ikeda K; Okuyama M (1981). **Effects of restricted feeding during the rearing period and of induced molting during the laying period on laying performance of hens.** *Japanese Poultry Science* 18(2): 67-77.

Kagoshima Prefectural Poultry Experiment Station, Sendai-shi 895, Japan.

NAL Call Number: 47.8 N57

Two experiments were carried out in each of 9 poultry research stations. In each station one group of chickens was fed to appetite as a control and the others were given a restricted amount of feed every other day so that feed intake from 4 to 18 weeks of age was calculated to be 60% of that for unrestricted controls. After 18 weeks of age, all of the chicks were fed to appetite. At 20 weeks of age, the hens of both groups were sub-divided into 4 sub-groups each. The hens of the first and second sub-group were force-molted at 80 and 92 weeks of age, respectively. The hens in the third and the last sub-group were force-molted at 56 and 68 weeks of age, respectively, and all the hens were again force-molted at 96 weeks of age. All hens were kept until 128 weeks of age. Restricted feeding delayed sexual maturity, but resulted in larger first egg than those from hens fed to appetite. Bodyweight and daily feed intake of hens of the restricted group were less than for those of the unrestricted hens throughout the laying period, while mean egg weight of the former was less than that of the latter. Egg production of unrestricted hens was lower than that of hens on the restricted feeding programme after peak production. Among the 4 sub-groups on the restricted feeding programme, average egg production was almost the same regardless of age at the start of molting. In contrast, with unrestricted hens average egg production of the sub-group forced to molt twice at 56 and 96 weeks of age was the highest. Over 128 weeks the feed intake/kg eggs was significantly less for restricted hens than for unrestricted hens. Among the 4 sub-groups on the restricted feeding programme, little difference was observed in feed intake/kg eggs. Among the sub-groups on full-feeding, the lower the age at first molting, the lower was the feed intake. Haugh units of eggs laid by restricted hens were higher than for unrestricted hens. Forced molting increased both thickness of egg shell and Haugh unit of the

eggs, though the difference in Haugh units before and after the second forced molting was not significant. After forced molting, restricted hens recovered egg production more rapidly than did unrestricted hens.

Descriptors: feed intake, hens, egg production, molting, hatching season, laying performance, molt, induction, nutrition, food restriction, age at first egg, sexual maturity, molt induction

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Katrich NI (1982). **The intensity of induced moult and its relationship with the physiological condition of hens before the application of stress.** *Trudy, Kubanskii Sel'skokhozyaistvennyi Institut* No. 212(240): 47-51.

For hens which continued egg production after they had dropped 2-3 primary wing feathers (group 1), hens which did not start moulting and continued egg production (group 2), hens which were in an advanced stage of moult (3-5 wing primaries) and had stopped egg production (group 3), and hens which did not molt but stopped egg production (group 4), the rate of regrowth of wing primaries 50 days after molt induction was 69.6, 54.2, 70.0 and 58.9% resp. The differences of the 1st and 3rd groups from the 2nd and 4th were highly significant.

Descriptors: moult, egg production

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Keshavarz, K. (1995). **Impact of feed withdrawal and dietary calcium level on force-rested hens.** *The Journal of Applied Poultry Research* 4(3): 254-264.

Cornell University, Ithaca, NY.

NAL Call Number: SF481.J68

Descriptors: hens, laying performance, food deprivation, rest, duration, experimental diets, calcium, nutrient content, egg production, egg mass, egg shell quality, specific gravity, bone ash, body weight, force resting, recovery diets

Khan AG; Lad BK (1996). **Consequences of induced rest feeding programme (IRFP) on dwarf layer.** *Indian Journal of Animal Sciences* 66(2): 177-183.

Dep. Poultry Sci., Jawaharlal Nehru Krishi Vishva Vidyalaya, Jabalpur, Madhya Pradesh 482 004 India

NAL Call Number: 41.8 IN22

Response of dwarf layers to variable induced rest feeding programme (IRFP) was studied. Seven days fasting followed by 2, 4 and 6 weeks of 20 g feed/bird/day constituted T1, T2 and T3 treatments. Data for 68 to 102 weeks of age was analysed along with that of the control. IRFP initiated shedding of primary feathers but the secondaries remained intact. T3 hens remained smallest in body size post-IRFP but T1 and T2 remained similar in size as that of the control. Control group hens laid more number of eggs than all treatment groups during IRFP periods. Post-IRFP to a fixed 28-weeks T1, T2 and T3 hens laid more eggs than the control, but the superiority was lost when post-IRFP to 102 weeks production was analysed. For 68 to 102 weeks of age, IRFP egg losses were compensated by higher peak and persistency in treatments as compared with the control. T3 hens laid heaviest egg. Feed

consumption was associated linearly with the duration of IRFP irrespective of treatments. T3 group hens consumed less feed accounting 17.56% saving for production of 1 egg. In terms of economics, feed savings during IRFP equally contributed as the egg laid in the net financial gain which ranged from Rs -4.65 to + Rs 40.46 bird for different treatments.

Descriptors: economics, feed consumption, diet, egg production

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Kharitonov MM (1973). **Effect of an artificial moult on the productivity of laying hens and the hatchability of their eggs.** [Vliyanie iskusstvennoi lin'ki kur-nesushek na ikh produktivnost' i inkubatsionnye kachestva yaits.] *Volgogradskii Sel'skokhozyaistvennyi Institut* 50: 68-71

Moulting was induced in 1850 birds by depriving them of light, water and food for 2 days, after which each of the 3 factors was restored gradually. Compared with control birds in which moulting was not induced, treated females on resuming lay produced eggs which were 1.6 g heavier and had shells 16.4% thicker. For treated and control females resp., hen-housed egg production was 64.2 and 58.5%, egg fertility 82.1 and 74.6%, hatchability of eggs set 78.3 and 75.5%, and chick weight at 30 days of age averaged 235 and 224 g.

Descriptors: moult, induction, laying performance

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Khashem Y (1989). **The effect of interrupted light.** *Ptitsevodstvo* (No. 6): 30-32.

NAL Call Number: Z5074 P8R4

Data were obtained on the egg-type commercial cross Zarya-17 (63 hens plus 6 old and 6 young cocks per group). The experimental group was maintained under a light regime which corresponded to the photoperiod allowed to the controls during growth, and was 2-h light:4-h darkness:8h-light:10-h darkness during the egg laying period. The controls were allowed light decreasing from 23 1/2 h daily at the beginning of growth to 9 h at 17 wk of age, and then increasing to 14-h daily. Egg production in the 1st yr of lay averaged 261.2 and 260.8 in the 2 groups resp., the percentage of eggs suitable for incubation 80.8 and 79.9, and hatchability of eggs set 90.3 and 86.1%. At 74 wk of age, the moult was induced by withdrawal of food and water for 4 days. For eggs laid in the 2nd cycle, egg fertility was 95.3 and 90.7%, hatchability of fertile eggs 90.8 and 87.5%, and hatchability of eggs set 86.5 and 79.4%. Egg production in the 34 wk after the moult averaged 138.5 and 141.0 in the 2 groups.

Descriptors: light regime, egg production, egg fertility, egg hatchability

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King DF; Trollope GA (1934). **Force-molting of hens and all-night lighting as factors in egg production.** Circular: Agricultural Experiment Station of the Alabama Polytechnic Institute No. 64: 1-7.

Auburn : Agricultural Experiment Station of the Alabama Polytechnic

NAL Call Number: 100 AL1S (2) no.64

Knowlton FL (1936). **Force-molting of white leghorn hens.** *Station circular: Agricultural Experiment Station, Oregon State Agricultural College* 119: 1-8.
NAL Call Number: 100 Or3 no.119

Koelkebeck KW; Parsons CM; Douglas MW; Leeper RW; Jin S; Wang X; Zhang Y; Fernandez S (2001). **Early postmolt performance of laying hens fed a low-protein corn molt diet supplemented with spent hen meal.** *Poultry Science* 80(3): 353-357.
Department of Animal Sciences, University of Illinois at Urbana-Champaign, 61801, USA.
kkoelkeb@uiuc.edu
NAL Call Number: 47.8 AM33P

We used a total of 504 commercial Single Comb White Leghorn hens (69 and 65 wk of age) in each of two experiments, and hens were induced to molt by feed withdrawal only. Feed withdrawal lasted for 12 and 11 d, and hens lost 26 and 25%, body weight in Experiments 1 and 2, respectively. All hens were then weighed, and seven replicate groups of 12 hens each were assigned to molt diet treatments. In Experiment 1, diets consisted of a corn basal diet (7.9% CP) or corn basal diet supplemented with 7.5 or 10% spent hen meal (SHM) each from two different sources. In Experiment 2, the corn basal diet or this diet supplemented with 5 or 10% SHM alone or 5% SHM plus Met, Lys, and Trp was evaluated. A molt diet of 16% CP corn-soybean meal was used as a positive control in both experiments. Molt diets were fed for 15 d in both experiments, at which time all hens were fed a 16% CP layer diet.

Performance was measured for 8 wk following the beginning of feeding the layer diet.

Feeding the low-protein corn molt diet supplemented with 5 to 10% SHM improved early postmolt egg production performance and body weight gain compared with hens fed the corn basal diet alone. The 7.5 and 10% SHM diets yielded early postmolt performance that was not significantly different ($P > 0.05$) from that of hens fed the high-protein (16% CP) diet. Supplementing the 5% SHM diet with amino acids generally did not significantly improve performance. The present study thus indicates that improved early postmolt performance may be achieved by supplementation of a low-protein corn molt diet with 5 to 10% SHM.

Descriptors: Chickens--physiology--PH; Dietary Proteins--administration and dosage--AD ; Food Deprivation; Molting; Reproduction ; Animal Feed

Koelkebeck KW; Parsons CM; Leeper RW; Moshtaghian J (1991). **Effect of protein and methionine levels in molt diets on postmolt performance in laying hens.** *Poultry Science* 70(10): 2063-2073.

Department of Animal Sciences, University of Illinois, 324 Mumford Hall, 1301 W. Gregory Drive, Urbana, Illinois 61801, USA.

NAL Call Number: 47.8 AM33P

In 3 experiments, laying hens 70, 65 and 96 weeks old were induced to moult by fasting (feed only) until 26 to 28% body weight loss occurred. Molt diets containing 16, 13 or 10% crude protein (CP) without or with 0.15% methionine were then fed until egg production reached about 10%, at which time all hens received a 16% CP layer diet for 30 weeks in experiments 1 and 2 and for 4 weeks in experiment 3. In experiment 1 (summer), hens regained body weight more rapidly, returned to production faster, and had larger egg weights (weeks 1 to 4)

when fed the 16 or 13%-CP molt diets than when fed the 10%-CP molt diet. Long-term egg production, egg yield (grams of egg per hen per day) (weeks 1 to 30), and feed efficiency (weeks 1 to 8) were greater for hens fed the 16 or 13%-CP molt diets compared with those fed the 10%-CP molt diet. Methionine supplementation had no effect on postmolt performance. In experiment 2 (winter), the only significant treatment effect was that methionine supplementation increased egg weight (weeks 1 to 30). Molt diet had no consistent effect on egg specific gravity during the last 4 weeks of the postmolt production period in experiments 1 or 2. The effects of the dietary treatments on early postmolt performance in experiment 3 (early autumn) were similar to those observed in experiment 1. Results indicate that protein content, but not methionine supplementation, in molt diets influenced postmolt performance of hens during the summer and early autumn experiments, but not in the winter experiments.

Descriptors: Egg production, protein intake, moulting, methionine, supplements

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Koelkebeck KW; Parsons CM; Leeper RW; Jin S; Douglas MW (1999). **Early postmolt performance of laying hens fed a low-protein corn molt diet supplemented with corn gluten meal, feather meal, methionine, and lysine.** *Poultry Science* 78(8): 1132-1137. Department of Animal Sciences, University of Illinois at Urbana-Champaign, Urbana 61801, USA. kkoelkeb@uiuc.edu

NAL Call Number: 47.8 AM33P

Commercial White Leghorn hens (65, 63, or 70 wk of age in Experiments 1, 2, and 3, respectively) were induced molted by feed withdrawal until approximately 28% body weight was lost. All hens were then weighed, and seven replicate groups of 12 hens each were fed molt diets. In Experiment 1, three diets consisted of a corn basal diet (7.9% CP) or this diet supplemented with corn gluten meal (CGM) and Lys or feather meal (FM), Met, and Lys. In Experiments 2 and 3, varying levels of FM and FM with Met and Lys were evaluated. A 16% CP corn-soybean meal diet was used as a positive control in all experiments. The molt diets were fed for 17, 15, and 17 d in Experiments 1, 2, and 3, respectively, and production performance was measured for 8 wk from the beginning of feeding the layer diet. In all experiments, hens fed the 16% CP corn-soybean meal molt diet returned to egg production and regained body weight at a faster rate than did hens fed any of the other diets. In Experiment 1, early egg production of hens fed the corn basal diet supplemented with CGM and Lys or supplementation with FM, Met, and Lys was greater ($P < 0.05$) than that of hens fed the basal diet alone. In Experiment 2, very early egg production (Week 1) and body weight gain were lower ($P < 0.05$) for hens fed the corn basal diet than for hens fed the basal supplemented with FM, Met, and Lys. The addition of 5.75 or 8.5% FM or 5.75% FM plus Met and Lys generally increased ($P < 0.05$) early egg production and postmolt body weight gain compared to the corn basal diet in Experiment 3. The present study thus indicated that improved early postmolt performance may be achieved by supplementation of a low-protein corn molt diet with various combinations of CGM, FM, Met, and Lys.

Descriptors: Chickens--physiology--PH; Dietary Proteins; Molting; Reproduction ; Animal Feed; Corn; Feathers; Lysine--administration and dosage--AD; Methionine--administration and dosage--AD; Weight Gain

Koelkebeck KW (1991). **Molting programs for layers: effect of dietary protein and methionine and length of fast on post-molt performance.** *Poultry Adviser* 24(12): 49-51.

University of Illinois. USA.

NAL Call Number: SF481 P622

In experiments 1 and 2 during summer and winter, White Leghorn chickens 65 and 70 weeks old were fed on maize/soyabean diets containing 10, 13 or 16% protein with 0 or 15% methionine until production reached 10%. A 16% protein layer diet was then fed for 30 weeks. In experiment 3, Leghorn chickens, 65 weeks old were fed on maize/soyabean diets containing 10 or 16% protein or 10% protein plus 0.25% lysine, 0.16% arginine, 0.10% threonine and 0.15% methionine or starved for 4 days and then fed on a 16% protein diet. Controls were not moulted. All diets were fed until 14% production was reached and then 16% protein diets were fed for 30 weeks. Body weight gain and egg production data are given in a table. In the summer experiment post-moult egg production in weeks 1 to 10 was 60.2, 64.9 and 65.1 with diets containing 10, 13 and 16% protein, respectively. In weeks 1 to 20 and 1 to 30 egg production was significantly higher in hens fed on the 16% protein diet compared with hens on the 10% protein diet. Feed intake was higher and body weight gain to 3 weeks lower for hens fed on the 10% protein diet compared with the hens on the 13 and 16% protein diets (100.4, 94.5 and 93.4 g/hen daily and 401, 431 and 441 g/hen, respectively). In the winter experiment, feed intake, body weight gain, egg production and egg weight were not different between hens fed on the different protein moult diets. In experiment 3, overall egg production was lowest in the non-moulted controls compared with hens fed 16% protein diets at week 30 (65.7 vs. 74.6). Overall egg weights were higher for the non-moulted controls than for hens fed 10% protein diets, 64.2 vs. 62.3 g/egg. Egg specific gravity at week 30 was lowest in the non-moult hens, 1.0736, and highest in hens fed on the 10% protein diet with amino acids, 1.0782 g/cm³. Egg shell quality was not affected by the short-term 4-day starvation. It was concluded that early and post-moult performance may be increased by protein moult diets containing 16 and 13% protein compared with 10% protein diets and that long-term egg production was not adversely affected by 4-day starvation periods used to induce moult. Methionine supplementation of moult diets had no benefit on post-moult egg production.

Descriptors: feed intake, liveweight gain, egg production, egg weight, protein intake, hens, egg quality, moulting, starvation, methionine, intake, soyabeans

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Koelkebeck KW; Parsons CM (1990). **Nutritional aspects of molting programs.** *Poultry Adviser* 23(2): 43-44.

University of Illinois at Urbana-Champaign, 1301 West Gregory Drive, Urbana, Illinois 61801, USA.

NAL Call Number: SF481 P622

Experiments in summer and winter, each with 500 White Leghorn hens induced to moult by feed restriction, indicated that early post-moulting layer performance could be enhanced by increasing protein in the diet from 10 to 13 or 16%. However, these effects may be influenced by environmental temperature, since they were observed in the summer but not in the winter

study. Long-term post-moulting performance was not substantially affected by using diets ranging in protein content from 10 to 16%, with or without added methionine.

Descriptors: moulting, restricted feeding, hens, protein intake

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Kummerfeld N; Luders H (1978). **Effect of dark periods on the food and water intake of adult chickens. [Futtermverzehr und Wasserkonsum von Hühnern bei Dunkelheit].** *Deutsche Tierärztliche Wochenschrift* 85(6): 212-216.

Tierärztliche Hochschule, Buntweg 17, D-3000 Hannover, German Federal Republic

NAL Call Number: 41.8 D482

The influence of 12 hour light - dark cycles and 84 hours continuous darkness on the food and water intake were examined in 15 caged hens and 15 caged cocks. Once the light phase was over the chickens stopped their food and water intake during the first hour of the dark phase. Only in the cocks was an irregular, slight food and water intake ("nibbling") observed in the later period of darkness. Food and water intake of the cocks was maintained in the dark period corresponding to their physiological means in the intermittent 12 hour light period when the dark time had suddenly been prolonged to 84 hours. Hens subjected to 84 hours of darkness showed a reduction of food and water intake by 20% and a change in the food rhythm. No signs of molting were observed in the period of prolonged darkness.

Descriptors: animal behavior, lighting, feeding behavior, drinking, hens, feed intake, water intake

Lange K (1977). **Forced moult in different strains of layers. [Die Zwangsmauser bei verschiedenen Legehennenherkünften].** *Deutsche Geflügelwirtschaft und Schweineproduktion* 29(41): 1096-1099.

Hessische Landesanstalt für Leistungsprüfungen in der Tierzucht, Neu-Ulrichstein, German Federal Republic

NAL Call Number: SF481 D48

At 506 days of age, a forced moult was induced in 6 groups of white-egg and 3 groups of brown-egg layers (140 females /group). The white-egg strains involved were Shaver Starcross 288, Babcock B 305, Hisex White and HNL, and the brown-egg strains were Warren SSL and Babcock B 380. Food and light were withheld for 3 days, and were reintroduced gradually. Data on egg production in the 2nd laying period are tabulated. In the white-egg layers, egg production decreased to less than or equal to 1% within 6 days of beginning treatment v 9 days in the brown-egg groups. Egg production remained at less than or equal to 1% for 12 and 9 days resp. The time taken to regain 50% production was significantly shorter in the Hisex Whites and Babcock B 305s (43 and 45 days resp.) than in all other groups (54-60 days). In the HNLs, production after moulting averaged 83% of that in the pre-moult period v 72-76% for the other white-egg groups. Egg production averaged 158 eggs in the white-egg groups v 116 in the brown-egg groups, and hen-day egg production 56.6 v 41.4%. The unsatisfactory performance of the brown-egg layers was ascribed to the laying pause being too short. Overall, av. egg weight, the proportion graded 1-3, and egg-shell strength were improved over values in the pre-moult period.

Descriptors: moult, induction, egg production, strain differences

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- Lee K; Holiday OR; Petty CE (1980). **Effects of forced molt and rest on egg production, feed efficiency, and mortality of Single Comb White Leghorn hens.** *Poultry Science* 59(7): 1566.
 Dep. Agriculture, Univ. Arkansas, Pine Bluff, AR 71601, USA.
 NAL Call Number: 47.8 AM33P
 Descriptors: egg production, molting, feed conversion efficiency, hens
- Lien RJ; Roark LE (1993). **Both feed and daylength restriction are important in recycling laying hens.** *Highlights of agricultural research - Alabama Agricultural Experiment Station* 40(1): 14.
 Auburn University, Ala.: The Station.
 NAL Call Number: 100 AL1H
 Descriptors: hens, restricted feeding, light, egg production, molting
- Loedl J; Augustynski M; Wezyk S (1977). **The use of induced moulting in hens kept for two seasons.** [Zastosowanie przymusowego przepierzania w dwusezonowym uzytkowaniu kur niosek.] *Roczniki Naukowe Zootechniki* 4(1): 249-257.
 NAL Call Number: SF1 R63
 Data are obtained over 2 yr on 455 Leghorn hens that were allowed to moult naturally and on 400 hens subjected to induced moult in the 13th mth of production using withdrawal of food for 7 days (some food was allowed on the 6th day), water for 4 days and light for 4 days, followed by light restriction to 8 h daily for 26 days. For the 2 groups resp., the performance in the 2nd egg production cycle, lasting 9 mth, was as follows: egg production percentage, 45.1 and 49.2; egg production, 123.2 and 134.3; egg weight, 65.7 and 65.6 g; egg mass, 8.09 and 8.81 kg; consumption of food/kg eggs, 5.45 and 3.85 kg; mortality, 11.6 and 12.2%; body weight at the end of experiment, 2184 and 2045 g.
 Descriptors: moult, induction, laying performance
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- Majun GK; Payne CG (1977). **Autoclaved rice bran in layers' diets.** *British Poultry Science* 18(2): 201-203.
 Univ. Sydney, Poultry Husbandry Research Foundation, Camden, NSW 2570, Australia.
 NAL Call Number: 47.8 B77
 In an experiment lasting 16 weeks 160 sixteen-month-old White Leghorn X Australorp hens, previously force-molted, were caged singly and fed on one of 5 diets with 17.0% crude protein. Control diet was based on wheat and soya bean meals; test diets had 30% rice bran, raw or autoclaved 20 min at 120 deg C, or 60% raw or autoclaved. For diets in that order, egg production/100 hen days was 73.5, 74.2, 75.6, 67.1 and 73.4 and egg mass was 48.4, 49.6, 49.1, 43.3 and 48.1 g/hen daily. Shell thickness and yolk colour were adversely affected by 60% raw rice bran.
 Descriptors: hen feeding, rice bran
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- Matsuzaki S; Takemoto Y; Murakami T (1994). **Establishment of long-term utilizing technology of hen in windowless chicken house. Lighting method during and after forced resting period for intermittent lighting chicken. 2nd report. (Kumamoto Prefectural Agricultural Res. Center Livestock Laboratory S).** *Kumamotoken Nogyo Kenkyu Senta Chikusan Kenkyujo Shiken Seisekisho (Annual Report of the Kumamoto Prefectural Agricultural Research Center Animal Husbandry Research Insititute)* 1994: 134-139.
 Descriptors: laying hen, photic stimulation, egg-laying, chicken house, rearing management, lighting condition, feed efficiency, gravimetry, chicken egg, egg shell, energy saving, strain specificity
- McKeen WD (1984). **Feeding grape pomace to leghorn hens as an alternative to starvation to induce a molt.** *Poultry Science* 63(Suppl.1): 148-149.
 Univ. Calif., Agric. Cooperative Extension, 777 E. Rialto Ave., San Bernadino, California
 NAL Call Number: 47.8 AM33P
 Descriptors: milo, metabolizable energy, protein, vitamin, mineral, weight loss
- McKeen WD (1979). **Hot weather and force molting (Hens).** *California Poultry Letter: University of California, Cooperative Extension* Aug: p. 1-3.
 NAL Call Number: SF481.C3
- McKeen WD (1978). **The use of grape pomace in a force molt feed.** *Progress in Poultry "Through Research."* Sept (13): 4 p.
 University of California, San Bernardino County Calif.: Cooperative Extension, University of California.
 NAL Call Number: SF487.8.C2P76
 Descriptors: hen feeding, molting, grape pomace, egg production, laying performance, production costs, statistics
- McKeen WD (1977). **The use of a mixture of 50 percent grape pomace and 50 percent whole olive meal as a portion of a force molt ration.** *Progress in Poultry "Through Research."* July (8): 6 p.
 San Bernardino County Calif. : Cooperative Extension, University of California.
 NAL Call Number: SF487.8.C2P76
 Descriptors: hens, feed requirements, grape pomace, olive pulp, laying performance, egg production, statistics
- Mehta VS; Lahkotia RL; Singh B (1986). **A study on forced resting and recycling of White Leghorn layers.** *Indian Journal of Animal Production and Management* 2(3): 138-140.
 Department of Livestock Production and Management, College of Veterinary and Animal Science, Sukhadia University, Bikaner 334 001, India
 NAL Call Number: SF55 I4I53
 At the end of an 8-month laying period, a laying pause was induced in 255 White Leghorns by withdrawal of water and feed for 2-3 days, followed by restricted feeding for 4 wk. During

the pause, hen-day egg production was <5% vs. 39% in 255 untreated layers (controls). After the resumption of ad lib. feeding, egg production returned to the level of the controls within 13 days. In the 7 months following the pause, hen-day egg production averaged 43.95% vs. 33.2 in controls, and feed consumed per egg 216.2 g vs. 261.1. Over the total 16-month period, egg production in the 2 groups averaged 47.6 and 44.6% resp., and feed consumed per egg 199.1 and 222.1 g.

Descriptors: laying performance, molt, induction

Monteiro NM da C; Andrade AN de; Britto DPP de S; Guimaraes JF; Sinzato D; Costa FA (1971). **A comparison between forced and natural moult in White Leghorn hens, caged at two different densities. [Comparacao entre muda forcada e muda natural em galinhas Leghorn Brancas alojadas em gaiolas, em duas densidades.]** *Pesquisa Agropecuaria Brasileira (Veterinaria)* 6(4): 33-36.

Escritorio de Pesquisas e Experimentacao, Campo Grande, GB, ZC-26, Brazil

NAL Call Number: S15 P42

Experiments carried out in Rio de Janeiro with a total of 3200 hens, caged singly or 2 to a cage, showed that there were no significant differences in egg production or quality characters between hens subjected to force moulting, achieved by providing no food or water for 48 h, followed by reduced rations for a further 12 days, and those moulting naturally. Egg production was highest during June-Aug., and it was higher in hens caged singly than in birds in a shared cage. Albumen density and Haugh unit scores were affected by season but not by housing density or type of moulting, whereas egg weight was affected by type of moulting, housing density and age of hen. It was concluded that there is a need for new methods of force moulting specially adapted for tropical conditions.

Descriptors: egg production, egg quality, egg weight, moult, induction, management, housing, cage density, seasons, age, hens

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Muhammad MUH; Muhammad A; Shah STH; Firdous R; Ahmad R (2000). **Post-moult egg quality of commercial layers induced to moult under various fasting and feeding regimes.** *Acta Veterinaria (Beograd)* 50(2/3): 131-136.

Department of Zoology, Government College, Faisalabad, Pakistan.

NAL Call Number: 41.8 V6447

The effect of various starvation and feeding regimes during moulting on post-moult egg quality characteristics of commercial layers was studied. The experiment was carried out on 180 Babcock laying hens available at the age of 122 weeks during the second production cycle after the first moult induction. The birds were kept in single deck type cages comprising 18 experimental units of 10 birds each, that had previously been assigned to six treatment groups having three (5, 10, 15 days) starvation regimes x two (once-a-day and skip-a-day) feeding regimes in a factorial arrangement with three replications each. During the experimental period each bird was given 0.80 kg layer mash weekly. A total of 18 randomly selected eggs (one egg per experimental unit) taken every week were used for the study of egg quality (egg weight (g), shell thickness (mm), Haugh unit values and yolk index). The

starvation and feeding regimes applied during the induced moult did not have any significant effect on post-moult egg weight, shell thickness, or yolk index. However, the differences in post-moult Haugh unit values in layers induced to moult under various starvation regimes and their interaction with feeding regimes were significant, whereas feeding regimes did not influence the mean Haugh unit values.

Descriptors: egg quality, starvation, feeding, egg weight, eggs, hens, poultry, moulting , management, egg shell thickness

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Mushtaq-Ul-Hassan M; Akram M; Sattar B; Raza NM; Dar B; Khanum S (2001). **The influence of various rations during the molt on subsequent egg number and egg quality characteristic in commercial layers.** *Acta Veterinaria* (Beograd) 51(2/3): 157-162.

Department of Zoology, Government College, Faisalabad, Pakistan.

NAL Call Number: 41.8 V6447

A total of 288 laying hens, randomly divided into 18 experimental units with 16 birds each, were used in the study. Before the start of the molt induction all the birds were given a pre-molt treatment of vaccination and medication for one week to eliminate internal parasites and to protect against various diseases. Forty-eight birds (group A), which served as the control were continued on Ration No.3 (16.5% crude protein (C.P.) + 2850 Kcal/kg metabolizable energy (M.E.)). The remaining 240 birds were divided into 5 groups viz. B, C, D, E, and F, which were starved for 14 days for the induction of molting. Only water was given to these birds. After that, different rations were offered with different C.P. and M.E. contents for 14 days. Restricted feed (Ration No. 3) was given to group B on an alternate day basis (after 48 hours). Corn (9% C.P.), Ration No. 1, (20% C.P. + 2800 Kcal/kg M.E.), Ration No. 2 (15% C.P. + 2700 Kcal/kg M.E.) and Ration No. 3 were offered to the hens of groups C, D, E and F, respectively. All the groups were served with the same feed at the termination of the molting treatment. Post-molt egg number (5.57 plus or minus 0.52), egg weight (66.78 plus or minus 5.41 g) and shell thickness (0.39 plus or minus 0.04 mm) were significantly higher in birds which were subjected to the induced molt. Among the molted groups, the maximum number of eggs (5.80 plus or minus 0.48) were produced by the birds given corn during the molt, whereas the maximum egg weight (68.30 plus or minus 5.58) was noted in birds which were given Ration No.3. Shell thickness was greatest (0.41 plus or minus 0.04 mm) in birds which were treated with the restricted diet during the molt. Post-molt yolk index, Haugh units and meat spot values did not show any significant variations between the groups.

Descriptors: crude protein, egg characters, egg quality, egg weight, eggs, feeding, feeds, hens, maize, metabolizable energy, molt, molting, poultry, starvation

Mushtaq-Ul-Hassan M; Akram M; Shah STH; Firdous R; Ahmad R (2000). **Post-molt egg quality of commercial layers induced to molt under various fasting and feeding regimes.** *Acta Veterinaria* (Beograd) 50(2-3): 131-136.

Department of Zoology, Government College, Faisalabad, Pakistan

NAL Call Number: 41.8 V6447

The effect of various starvation and feeding regimes during moulting on post-moult egg quality characteristics of commercial layers was studied. The experiment was carried out on 180 Babcock laying hens available at the age of 122 weeks during the second production cycle after the first moult induction. The birds were kept in single deck type cages comprising 18 experimental units of 10 birds each, that had previously been assigned to six treatment groups having three (5, 10, 15 days) starvation regimes X two (once-a-day and skip-a-day) feeding regimes in a factorial arrangement with three replications each. During the experimental period each bird was given 0.80 kg layer mash weekly. A total of 18 randomly selected eggs (one egg per experimental unit) taken every week were used for the study of egg quality (egg weight (g), shell thickness (mm), Haugh unit values and yolk index). The starvation and feeding regimes applied during the induced moult did not have any significant effect on post-moult egg weight, shell thickness, or yolk index. However, the differences in post-moult Haugh unit values in layers induced to moult under various starvation regimes and their interaction with feeding regimes were significant, whereas feeding regimes did not influence the mean Haugh unit values.

Descriptors: egg-quality, starvation, feeding, egg-weight, eggs, hens, poultry, moulting, management, egg shell thickness

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Ohtsuka S (1986). **Effects of limited lighting and restricted feeding on the resumption of laying after forced molting.** *Japanese Poultry Science* 23(6): 334-343.

National Inst. Animal Industry, Ikenodai 2, Kuki, Inashiki, Ibaraki 305, Japan.

NAL Call Number: 47.8 N57

Molt was induced in hens aged 70 wk by withdrawing water for 3 days and food for 10 days. Light was restricted to 6 h per day during forced molting, and on the 11th, 21st or 31st day after the beginning of molt induction it was increased by 1 h daily to 16 h. In the control group, 16-h light was maintained throughout the experimental period. Food was restricted to 45 g daily per bird for 10, 20 or 30 days after forced molting, and given ad lib. thereafter. In the controls, food was given ad lib. throughout. Egg laying ceased within 4-7 days after the treatments began. Egg laying resumed within 13-24 days after lighting was increased or ad lib. feeding began. When birds were given either of the treatments for 40 days, egg production was relatively high when it resumed after the molt

Descriptors: laying performance, molt, induction

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Ohtsuka S (1989). **Effect of restriction of lighting and feed on resumption of laying after forced moulting.** [Efectos de la restriccion de iluminacion y alimentacion en la reanudacion de la puesta despues de la muda forzada.] *Revista Avicultura* 33(1): 19-22.

National Institute of Animal Industry, Tsukuba Norindanchi, Ibaraki 305, Japan

NAL Call Number: SF481 A9

The effect of restricted lighting (RL) or feed (RF) on resumption of laying after forced moulting induced by withdrawal of water and feed for 3 and 10 days, respectively, was studied in 2 experiments with 128 White Leghorn hens, 70 and 66 weeks old. In RL

treatment lighting was restricted to 6 h daily during forced moulting increasing by 1 h daily, to 16 h on the 11th, 21st or 31st day after initiation of forced moulting. Hens were fed to appetite throughout. In RF treatment feed was restricted to 45 g daily for 10, 20 or 30 days after forced moulting and given to appetite thereafter. Lighting was 16 h, daily, throughout. Cessation of laying began 7 days after initiation of forced moulting and continued throughout RL and RF. Laying was resumed in a mean 18, 14, 22 and 15 days after 10, 20, 30 and 40 days RL and 18, 18, 15 and 14 days after 10, 20, 30 and 40 days RF treatment (including the forced moulting period) with unrestricted lighting and feeding. Both treatments had a similar effect on egg production. Production was relatively high after 40 days RL or RF.

Descriptors: egg production, restricted feeding, light regime, moult

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Ovejero RI (1992). **Forced molting of commercial layer chickens. [La muda forzada de ponedoras comerciales].** *Mundo Ganadero* 3: 86-89.

Universidad Politecnica de Madrid, Spain

Descriptors in English: layer chickens, forced molting, animal husbandry methods, animal feeding, weight losses, laying performance, biological development, birds, chickens, domestic animals, domesticated birds, galliformes, livestock, losses, molting, performance, poultry

Palafox AL (1982). **Effect of force molt in performance of laying hens raised in Hawaii. (Diets, feed composition, egg quality).** *Zootecnica International* 10(October): 39-42.

NAL Call Number: SF600.Z6

Patel MB; McGinnis J (1981). **Induced cessation of egg production forced molting by addition of guar meal to the diet.** *Poultry Science* 60(7): 1710.

Dep. Animal Sci., Wash. State Univ., Pullman, Washington

NAL Call Number: 47.8 AM33P

Petersen J; Horst P (1976). **The effect of different treatments to induce a laying pause on body weight and laying performance. [Die Auswirkung unterschiedlicher Behandlungen zur Einleitung einer Legepause auf Körpergewichtsentwicklung und Leistungsgeschehen bei Legehennen.]** *Archiv für Geflügelkunde* 40(1): 13-22.

Institut für Tierproduktion, Lentzallee 75, 1000 Berlin 33, German Federal Republic

NAL Call Number: 47.8 AR2

In 900 HNL laying hybrids which were fed 2730 kcal metabolizable energy (ME) and 21% crude protein, moult was induced by 2 methods at 11, 15 or 18 mth of lay. Moult was induced (1) by the normal method (food, light and water deprivation for 4 days and maize restriction for 6 days), or (2) by a less severe method (similar restrictions for 3 and 2 days resp.). Level of nutrition had a significant effect on body weight before moult was induced. Body weight in all groups was significantly reduced by moult induction, but there was a lesser decrease using method 2 than method 1, and a slower recovery rate with method 2 after normal conditions were resumed. Egg laying was resumed 6 days earlier in hens given treatment 2

than in those given treatment 1, and performance in the first 100 days was similar in both groups. However, during the 6th-9th mth of the 2nd laying season, treatment-1 hens averaged 58.9 eggs, while treatment B hens laid considerably fewer (no figures given). Over the whole season, the more severely treated hens had significantly better egg production than the less severely treated hens. Egg weight was not affected by treatment, but shell stability was significantly better in hens given treatment 1 than in those given treatment 2.

Descriptors: moult, induction, body weight, laying performance, egg shell, age, animal nutrition, hens, egg production, moulting, poultry

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Rangel-Lugo M; Keshavarz K; McCormick CC (1986). **Effect of dietary energy dilution and restriction on pre- and post-molt performance of laying hens.** *Proceedings - Cornell Nutrition Conference for Feed Manufacturers* 1986: 57-63.

NAL Call Number: 389.79 C81

Descriptors: hens, diet, energy, restricted feeding, molt, performance ,

Rao SVR; Praharaj N K; Sunder GS; Raju MVLN; Reddy MR; Panda AK (2000). **Requirement of lysine and total sulfur amino acid for force moulted WL layers.** *Archiv fur Geflugelkunde* 64(5): 214-218.

Project Directorate on Poultry, Rajendranagar, Hyderabad, India

NAL Call Number: 47.8 AR2

An experiment was conducted to determine the lysine and total sulphur amino acid (TSAA) requirements of chemically force moulted White Leghorn layers for a period of 24 weeks (81 to 104 weeks of age). Hens (72 weeks of age) were moulted by feeding excess zinc (15,000 ppm) for 10 days, followed by ground yellow maize for 25 days. Two basal diets were prepared with 16.0 and 12.5% CP (basal diet A and B, respectively) with the same metabolizable energy content. Basal diet A was fed to a group (5 replicates x 10 birds each) of moulted and a group of non-moulted layers. Basal diet B was supplemented with three levels of lysine (0.60, 0.70 and 0.80%) and three levels of TSAA (0.50, 0.60 and 0.70%) in a 3 x 3 factorial manner and each one was fed to a group of 50 moulted hens, divided into five replicates. Hen-housed egg production was higher ($P < 0.05$) at 0.70% lysine and 0.60% TSAA (770 mg lysine and 680 mg TSAA intake per hen per day). The force moulted layer performance did not increase further at higher levels of lysine in the diet (0.80%). Feed intake, feed efficiency, albumin index, Haugh Unit score and shell thickness were also better at 0.70% lysine and 0.60% TSAA in the diet. Egg weight and shell percent were not influenced by dietary levels of lysine and TSAA in force moulted layers. The results of the present experiment indicated that force moulted WL layers require about 770 mg lysine and 680 mg TSAA of which 450 mg was methionine per hen per day.

Descriptors: hens, moulting, lysine, amino acids, sulfur amino acids, methionine, requirements, egg weight, egg production, egg quality, egg shell thickness

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- Ravindran R; Narahari D (1991). **Effect of different methods of force moulting on egg production, feed efficiency and mortality in White Leghorn hens.** *Journal of Veterinary and Animal Sciences* 22 (1): 128-133.
 Department of Poultry Science, Madras Veterinary College, Madras 7, India
 NAL Call Number: SF604 K42
 120 White Leghorn hens, housed in individual cages, were fed ad lib. with 15% protein layer mash from 72 to 112 weeks of age (controls) or were subjected to 4 different force moulting treatments. There were no significant differences between hens in the 5 groups in egg production, daily feed intake, feed conversion efficiency and mortality.
 Descriptors: restricted feeding, moulting, hens, molt, induction, egg production, feed conversion efficiency, mortality, tropics, laying performance, food consumption
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- Rose SP; Campbell V (1986). **Fatness of laying hens and induced molting regimens.** *British Poultry Science* 27(3): 369-377.
 NAL Call Number: 47.8 B77
 Descriptors: hens, obesity, molting, thinness, restricted feeding, egg weight, egg shell quality, egg albumen haugh units, egg production
- Rose SP; Campbell V (1985). **Fatness of laying hens and induced moulting regimes.** *Research and Development Note, Scottish Agriculture Colleges* (No. 28): 6 p.
 Poultry Husbandry Division, North of Scotland College of Agriculture, Parkhead, Craibstone, Bucksburn, Aberdeen AB2 9SX, UK.
 In 1100 Ross Brown laying fowls, aged 99 wk and which had been moulted at 60 wk, abdominal fatness was measured by calipers; the 324 birds with the lowest measurements were allocated to a "lean" group, and the 324 birds with the highest measurements to a "fat" group. The birds were then housed 3 to a cage. The birds were given 15 or 25 g whole wheat per day (skip-a-day feeding), and were molted for 2, 3 or 4 wk. After moulting, egg production was recorded for 22 wk after 50% production was reached. In the fat and lean groups resp., the number of days from the end of moult to 50% production averaged 23.95 and 21.37 ($P<0.01$), egg weight (0-11 wk) 67.93 and 67.38 g, egg production percentage (0-11 wk) 59.88 and 63.91 ($P<0.05$), and egg mass per bird per day (0-11 wk) 40.67 and 43.02 g ($P<0.05$). For 11-22 wk, only egg production percentage differed significantly between the 2 groups (44.35 and 48.10 resp.). The effects of moult length on laying performance were not significant, nor were most interactions involving fatness, moult length and feed level during moulting. The treatments did not affect egg quality or shell traits.
 Descriptors: body composition, obesity, laying performance, moulting, body fat, egg production, moult
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- Ruiz VJG; Gomez GLJ; Castro CE (1978). **Induction of forced molt (in laying hens) by using steroid hormones. [Induccion de la muda forzada mediante el empleo de hormonas esteroides].** *Revista - Facultad nacional de agronomia medellin. Universidad Nacional de*

Colombia. *Facultad Nacional de Agronomia* 31(1): 85-92.
Colombia, S.A., La Universidad.
NAL Call Number: 9.4 C717

Ruszler PL (1986). **Comparison of certain methods for induced molting of layers.** *College Park : The Conference. Proceedings - Maryland Nutrition Conference for Feed Manufacturers* p. 27-33.
NAL Call Number: 389.9 UN342
Descriptors: hens, diet, forcing, feathers (bird), losses

Ruszler PL; Minear LR (1997). **Comparison of induced molts using periods of four vs ten days feed withdrawal.** *Poultry Science* 76(Suppl. 1): 104.
Dep. Animal Poultry Sci., Virginia Tech., Blacksburg, Virginia 24061
NAL Call Number: 47.8 AM33P
Descriptors: body weight loss, commercial flocks, four versus ten days feed withdrawal, induced molts comparison, light exposure

Sakaida T; Sugiyama M; Kinbara H; Akama E; Enya K (1976). **Studies on feed restriction of layer.**
1. Effect of feed restriction on performance of layers. *Japanese Poultry Science* 13(6): 235-242.
Enya Poultry Experimental Station, Esaki Gifu-shi, Gifu-ken, Japan.
NAL Call Number: 47.8 N57
1. The study was with strain cross of White Leghorn (No. 1), two crossbreds of Rhode Island Red X White Leghorn (No. 2, 3) and strain cross of Rhode Island Red (No. 4), 162 of each. The layers were on full diet until 154 days of age, when they were divided into control and restricted group. Feed restriction was terminated at 519 days of age, and feed restriction rate was 90% of full diet of the control layers. Hens were subjected to force molting by starving for 7 days from 520 to 526 days of age, then for 365 days from 562 to 926 days were fed without restriction. Feed consumption of the restricted groups was 88.4% of the control during the experimental period. Hen-day egg production of restricted groups was 96.7% of the control group. The ratio of average egg weight and egg production per bird and day were 99.3% and 96.0% of the control groups. Feed conversion ratio was improved 0.24 by feed restriction. Bodyweight of the restricted groups was 88.6% of the control at 500 days of age. The restricted groups lost weight in the same ratio to feed intake. Egg production of both groups after force molting showed no effect of earlier feed restriction. (From summary.).
Descriptors: egg production, plane of nutrition

Samkharadze GS (1987). **Optimum microclimatic conditions for hens during forced moult.** *Aktual'nye problemy zoogigieny v promyshlennom zhivotnovodstve I ptitsevodstve. (Current problems of hygiene in intensive livestock and poultry farming).*, p.71-73
Moskovskaya Vet. Akad., Moscow, USSR.
The best conditions for keeping hens during artificially induced moult, in terms of feed consumption and subsequent hatchability, were provided by an environmental temperature of

21 deg C, relative humidity 76%, air exchange of 3.72 m³/hour per kg body weight, and an air flow rate of 0.24 m/s.

Descriptors: hens, poultry housing, moulting, microclimate

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Silva PCda; Zirlis AEF; Souza RNGde; Mercadante GdosS (1973). **Inositol and methionine supplementation of caged hens during the second year of lay, with or without forced moult.** [Suplementacao de inositol e metionina no segundo ciclo de postura, de galinhas em gaiolas, com e sem muda forcada.] *Boletim de Industria Animal* 30(1): 153-159.

Secao de Avicultura, Divisao de Zootecnia Diversificada, Sao Paulo, Brazil

NAL Call Number: 49 R324

288 hens in 8 groups, which had been in lay for 14 mth, were given supplements of inositol, methionine, inositol + methionine or no supplements; half the birds in each group were subjected to forced moult and half were not. Forced moult had a significant, beneficial effect on egg production, Haugh unit score and egg shell thickness, but did not affect egg weight, food conversion or mortality.

Descriptors: moult, induction, laying performance, egg production, egg shell, thickness, egg quality

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Silveiro E (1987). **Forced molting in layers.** [Muda forzada de gallinas ponedoras]. *ACPA* (Asociacion Cubana de Produccion Animal) no.3-4: 15-20. ISSN: 0138-6247

Instituto de Investigaciones Avicolas, Ciudad de La Habana, Cuba

NAL Call Number: SF17 A862

Descriptors in English: layer chickens, molting, feathers, oviposition, laying performance, progesterone, livestock management, glucocorticoids, quality, eggs, adrenal cortex hormones, animal morphology, animal products, biological development, birds, chickens, corpus luteum hormones, corticoids, domestic animals, domesticated birds, galliformes, hormones, integument, livestock, performance, physiological functions, poultry, progestational hormones, reproduction, sex hormones, sexual reproduction, steroids

Sitnikov PA; Kni YuI; Shevtsova LI (1974). **A study of the effect of artificial moulting on productivity of fowls.** [Izuchenie vliyaniya iskusstvenno vyzvannoi lin'ki na produktivnost' kur.] *Uchenye Zapiski Kazanskogo Gosudarstvennogo Veterinarnogo Instituta* 116: 163-165, 279.

In 17-mth-old White Leghorns, moult was induced by shortening the daily photoperiod from 1 Oct. and by restriction of food and water over a 6-day period. The daily photoperiod was gradually restored to 14 h, starting 1 mth after the shortening of the photoperiod. A similar group of untreated birds served as controls. In the 2 groups resp., egg production in the 2nd yr of lay averaged 186.2 and 168.7, and survival rate of hens to the end of the 2nd yr was 73.4 and 57.5%. Hatchability was 8.1% higher for eggs of treated than for those of untreated birds.

Descriptors: moult, induction, laying performance, egg production, mortality, egg hatchability

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Sloan DR; Harms RH (1988). **Recent research on resting of laying hens.** *Proceedings of the ... Florida Poultry Institute* (47): 31-35.

Gainesville: Florida Agricultural Extension Service.

NAL Call Number: SF481.2.F56

Descriptors: hens, egg production, molting, feeding frequency, feathers, fasting, regulations

Soldevila M; Siberio V; Soto RD (1984). **Recycling of hens by an induced rest period in laying.**

Original Title: Reciclaje de gallinas por medio de una pausa forzada en la postura.

Memoria, Asociacion Latinoamericana de Produccion Animal 19: 35-46.

Estacion Experimental Agricola, Colegio de Ciencias Agricolas, Univ. Puerto Rico, Puerto Rico.

White Leghorn hens were studied during the 1st laying cycle, the induced rest-moult period, and the 2nd laying cycle. In a randomized block design 12 replicates of 8 hens were used in 4 treatments: T1, induced rest-moult when the laying rate decreased markedly below 50%; T2, induced rest-moult by restricting feed for 6 days and water on the 1st day after laying for 12 months, followed by giving maize for 18 days and then layer's feed; T3, induced rest-moult by adding zinc oxide, 25 mg/g, feed, for 4 days after 12 months of laying, then giving layer's feed; T4, 1st laying hens which reached 50% laying intensity when the other groups were beginning their 2nd laying cycle. In the 2nd laying cycle production was 82.3%, egg weight 1.02% (100% = standard egg 56.75 g), eggs/kg feed 7.2 and mortality 1.0% for T4 and all significantly different from the other groups, 62.1-64.5, 1.07-1.08, 5.5-5.7 and 10.4-11.5.

Moult induced with ZnO and with restricted feed and water was 13 and 18 days, respectively.

Descriptors: egg production, moult

Starchikov N; Guzhva V; Dubovtseva M (1977). **Forced moult in a parent flock of egg-producing fowls. [Prinuditel'naya lin'ka roditel'skogo stada yaichnykh kur].** *Ptitsevodstvo* 9: 24-26.

NAL Call Number: Z5074 P8R4

Cross-288, line C hens (150/group) were subjected to induced moult by withdrawing food, water and light for 3 days. In the 1st group, both females and males were given the same treatment; in the 2nd group, the males were withdrawn before treatment and re-introduced later, and in the 3rd group, the males were withdrawn before treatment and replaced by young males after treatment. For the 3 groups resp., egg fertility over the 270 days after moulting averaged 82.3, 88.1 and 90.1%, and hatchability of egg set 89.7, 90.5 and 87.5%. The males were adversely affected by induced moult. Mortality in the 3 mth after induced moult was 15.3%; testis weight decreased from approx. 25 g before treatment to 1.2 g 1 mth after treatment, and returned to approx. 24 g by 120 days after treatment.

Descriptors: moult induction, reproduction, egg fertility, egg hatchability, mortality, testes, weight

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Stilborn HL; Waldroup PW (1990). **An evaluation of low-energy feedstuffs in diets for laying hens.** *Animal Feed Science and Technology* 27(4): 327-339.

P. W. Waldroup, Department of Animal Sciences, University of Arkansas, Fayetteville, AR

72701, USA

NAL Call Number: SF95 A55

Rice bran (RB), lucerne meal (AM), wheat bran (WB) and maize gluten feed (MGF) were used in laying hen diets containing metabolizable energy (ME) 2500, 2600, 2700 or 2800 kcal/kg and compared with diets based on maize and soyabean meal (MS). Each diet was given to 8 groups of 5 individually caged hens, following a forced molt. Hen performance was influenced more by the source of low-energy feed than by dietary energy content. Hen-day production, egg weight, feed intake, feed per dozen eggs and weight gains for AM, RB and WB diets were similar to that for MS control diets with equivalent energy content. Egg production was similar for hens fed on a low ME intake of 2600 kcal/kg with these feeds and hens given higher energy diets. Increasing MGF intake reduced hen performance. It is concluded that performance on the lower ME diets is highly dependent on the type of feed byproduct used.

Descriptors: egg production, energy sources, lucerne meal, rice bran, wheat bran, maize gluten meal, maize, wheat

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Summers JD; Leeson S (1977). **Sequential effects of restricted feeding and force-molting on laying hen performance.** *Poultry Science* 56(2): 600-604.

Dep. Animal and Poultry Science, Univ. Guelph, Ont., Canada N/G 2W1.

NAL Call Number: 47.8 AM33P

Laying hens were fed on diets with 15 or 17% crude protein, to appetite, restricted to 100 g/bird day or for 4 h each day (0800-1000 and 1430-1630 h). Dietary protein content had no significant effect on performance, but the full-fed birds ate more feed, produced a greater number of heavier eggs and gained more weight than restricted or time-limited birds. All birds were given a 15 or 17% crude protein diet to appetite after force-molting induced by removal of feed and water for a specified time. Pre-molt feeding had no effect during the molting period. During the post-molt laying cycle, birds that had previously been restricted or time-limited showed greater egg size and weight gain than birds fed freely during the first laying cycle. Dietary protein had no significant effect on production during the post-molt period. Egg shell deformation and Haugh unit measurements were not better after than before the molt.

Descriptors: egg production, feed restriction, forced molting

Sus H (1974). **Results of experiments on moult induction under practical conditions.**

[**Ergebnisse von Zwangsmausersversuchen in Praxisbetrieben.**] *Archiv fur Geflugelkunde* 38(1): 9-13.

Abteilung Kleintierzucht, Universitat Hohenheim, Stuttgart, German Federal Republic

NAL Call Number: 47.8 AR2

In the 1st experiment, with a flock of 500 HNLs, moult was induced after a 9-mth laying season by deprivation of water, food and light for 4 days. On days 5-10, half the flock were given 40 g oats/bird daily and the other half 40 g of an all-mash ration. In the 2nd experiment with 3 flocks (2HNL and 1 Hisex) totaling 4165 birds, the same methods of moult induction

were used, but food deprivation was more severe. Moulting was successfully induced in all flocks. After commencement of moulting, it took 35 days for birds in the 1st experiment to reach a laying rate of 50% and 41-47 days for birds in the 2nd experiment. Trends in laying performance in the 2nd laying season were similar to those in the 1st, but peak production was not so high. Egg weight averaged about the same after moulting as before in both experiments. The percentage of cracked and broken egg shells was reduced from 9.98% before molting to 3.1% in the 2nd mth after moulting, and remained below 6% for at least 6 mth in the 1st experiment. Albumen height and yolk height showed marked improvement after moulting. No practical problems were encountered.

Descriptors: egg production, egg weight, egg shell defects, egg quality, moulting, induction, laying performance, hens, moulting, animal husbandry, poultry

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Suwa K (1981). **Effect of forced-rest during early laying period on post-rest performance (Poultry).** *The Niwatori-no-kenkyu = Poultry journal* 56(12): 74-78.

Tokyo, Poultry Research Association.

NAL Call Number: 47.8 N64

Tatarchuk VV (1975). **Effect of some stress factors on the production characters of hens of different reproductive activity.** [Vliyanie nekotorykh stress-faktorov na produktivnye kachestva kur s raznoi polovoi aktivnost'yu.] *Ptitsevodstva* (No. 8): 94-96, 238.

Materialy Nauchnoi Konferentsii. Vsesoyuznyi Nauchno-Issledovatel'skii I

Tekhnologicheskii Institut

NAL Call Number: Z5074 P8R4

Groups of White Plymouth Rock hens of high, average and low reproductive performance (300 females /group) were used. Hens in the high-performance group had an av. production to 475 days of 205.7 eggs of 95.6% fertility and 93.2% hatchability, these values being 24, 14 and 10.3% resp. higher than in the low-performance group. When the females were subjected to forced moulting as a result of 10 days starvation, egg production in the 2nd laying period was 18.6 and 15.6% higher in the low-performance females than in the high-performance and av. ones resp. Following forced moulting hen viability was higher in the high- and av.-performance birds than in the low-performance ones (by 3.2 and 1.1% resp.).

Descriptors: laying performance, moulting, induction

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Thomas WG; Bray DJ (1976). **The response of broiler breeder hens to forced molting.** *Poultry Science* 55(5): Abstract No. 2100.

NAL Call Number: 47.8 AM33P

Descriptors: corn, oyster shell, light, mortality, egg, production, hatchability

Tonaka T (1980). **A comparison of force molting methods (in laying hens).** *Circular letter - Hawaii University, Cooperative Extension Service* October 1980, 89: 1-6.

NAL: SF481.H3

United States Office of Experiment Stations (1904). **Experiment station work, XXIII losses in manure, apple pomace for cows, macaroni wheats, rations for laying hens, sterilizing greenhouse soils, early molting of hens, tomatoes under glass, evaporation from incubator eggs, protection of peach buds, the keeping quality of butter, dandelions in lawns, curing cheese in cold storage.** *Farmers' bulletin / United States Department of Agriculture* no. 186: 32 p.

NAL Call Number: 1 Ag84F no.186

Verheyen G; Decuyper E (1988). **Production results following forced molting by a mild and a severe starvation procedure in brown laying hens (Warren S.S.L.) [Produktieprestaties na toepassing van een diervriendelijke ruimethode en een strenge, konventionele vastenmethode bij bruine leghennen (Warren S.S.L.).** *Landbouwtijdschrift* 41(2): Dutch edition 355-362; French edition 359-367.

Katholieke Univ. Leuven, Heverlee, Belgium, Lab. voor Fysiologie der Huisdieren [Lab. for Physiology of Domestic Animals]

NAL Call Number: 13 L233

Descriptors in English: layer chickens, molting, starvation, light regimes, laying performance, agriculture, animal production, animals, biological rhythms, birds, chickens, domestic animals, domesticated birds, egg production, galliformes, light, nutrition, nutritional phenomena, physical states, poultry, production, radiations, time, timing, vertebrates

Verheyen G; Decuyper E (1983). **Cessation of laying by induction in the hen. Effect of different methods on some production parameters and on the concentrations of thyroid hormones, prolactin, calcium, phosphorus, sodium and proteins in the blood serum (Force molting).** [Arret de la ponte par induction chez la poule. Effet de differentes methodes sur certains parametres de production et sur les concentrations en hormones thyroïdiennes, en prolactine, en Ca, P, Na et en proteines dans le serum sanguin.] *Revue de l'agriculture* 36(5): 1535-1559.

NAL Call Number: 13 R322

Yamagami Y (1990). **Recent trend of increase in the number of hens under forced molting, and some problems in this relation.** *Yokei no Tomo* 337: 28-38. ISSN: 0385-1648

Saitama Prefect. Poultry Exp. Stn.

Descriptors: rearing management, laying hen, molting, chicken egg, quality, egg-laying, economy, efficiency, egg shell, weight(gravity), freshness

Zhvikas EB (1976). **Effect of different methods of forced moulting on reproductive characters of laying hens.** [Vliyanie razlichnykh metodov prinuditel'noi lin'ki na vosproizvoditel'nye kachestva yaichnykh kur.] *Ptitsevodstvu* 4: 110-118, 142-143.

Sbornik Rabot. Pribaltiiskaya Zonal'naya Opytnaya Stantsiya po

NAL Call Number: Z5074 P8R4

Nine groups each of 75 Leghorn layers were treated as follows at the end of the 1st laying season: (1) controls, maintained under 14 h light daily and with access to food and water; (2)

light stress (light period increased to 24 h daily for 10 days, shortened abruptly to 8 h daily for 1 mth, and then lengthened to 14 h daily) but with access to food and water; (3) light stress and with access to water but starved for 6 days; (4), (5), and (6) as in (3) but starved for 8, 10 or 12 days resp.; (7) light stress, with access to food and water, and fed 0.7 g thyroid extract daily; (8) as in (7) but injected with 50 mg progesterone; (9) darkness, and withdrawal of water and food for 3 and 4 days resp. For the 9 treatments resp., egg production to the onset of forced moulting at 68 wk of age averaged 247, 247, 244, 238, 246, 238, 250, 250 and 246 v 216, 191, 222, 247, 230, 228, 213, 192 and 226 in the following 52 wk, group 4 producing significantly more and group 2 significantly less than the controls. Production to 43 wk after the onset of forced moulting was significantly better in groups 3, 4, 5, 6 and 9 (201, 230, 217, 216 and 212) and worse in group 2 (156) than in controls (178). Egg fertility 3 and 11 mth after forced moulting was generally higher than in birds aged 15-16 mth, but hatchability of eggs set was lower (69.4-87.1 and 64.9-73.8 v 88.8-95.1%). Corresponding values for hatchability in the control group were 87.7 and 80.5% v 92.9.

Descriptors: moult, induction, laying performance

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Zigic L; Srajber L; Masic B; Marinkovic V (1970). **The effect of forced molting on the physical properties and inner quality of eggs layed by New Hampshire hens.** *Veterinaria (Sarajevo)* 19(1): 66-71.

NAL Call Number: 41.8 V6494

Descriptors: albumin, yolk, shell

Zimmermann N (1993). **Effect of water additives during induced molt on postmolt performance of leghorn hens.** *Poultry Science* 72(Suppl. 1): 64.

Dep. Anim. Sci., Wash. State Univ., Puyallup, Washington

NAL Call Number: 47.8 AM33P

Zimmermann NG; Andrews DK (1990). **Performance of leghorn hens induced to molt by limited feeding of diets varying in nutrient density.** *Poultry Science* 69(11): 1883-1891.

Washington State University, Puyallup, WA

NAL Call Number: 47.8 AM33P

Descriptors: hens, hen feeding, nutrient density, restricted feeding, molt, laying performance, egg production

Zimmermann NG; Andrews DK; McGinnis J (1987). **Comparison of several induced molting methods on subsequent performance of Single Comb White Leghorn hens.** *Poultry Science* 66(3): 408-417.

Washington State University, Puyallup, WA

NAL Call Number: 47.8 AM33P

Descriptors: hens, molting, laying performance, fasting, restricted feeding, weight losses, guar meal, methionine, calcium

Zimmermann NG; Andrews DK; McGinnis J (1985). **Comparison of 12 induced-molt procedures.**
Poultry Science 64(Suppl.1): 204.

Department of Animal Science, Western Washington Research And Extension Center,
Washington State University Puyallup, Washington.

NAL Call Number: 47.8 AM33P

Descriptors: hen, guar meal, shell quality

Selected Websites

Induced Molting of Commercial Layers: North Carolina State University

<http://www.ces.ncsu.edu/depts/poulsci/techinfo/4Pst10.htm#top>

The Keys to Successful Induced Molting of Leghorn-type Hens

<http://www.ext.vt.edu/pubs/poultry/408-026/408-026.html>

Molting: Bovans Commercial White Egg Layer

<http://www.bovans.com/comlayer/clwtext1.htm>

MINERAL SUPPLEMENTS AND DEFICIENCIES

Abu-Serewa S; Karunajeewa H (1985). **A comparison of methods for rehabilitating aging hens.**

Australian Journal of Experimental Agriculture 25(2): 320-325.

Animal Res. Inst., Dep. Agric. Rural Affairs, Werribee, Victoria 3030, Australia

NAL Call Number: 23-AU792

Three of five groups of White Leghorn .times. Australorp hens aged 73 weeks, housed in cages, were fed a laying diet containing zinc (23.7 g/kg), or iodine (4.1 g/kg), or calcium (1.0 g/kg). The fourth group of hens was given only whole-grain barley while a fifth group given a normal laying diet served as the control. All groups were fed their respective diets until rate of lay dropped to 0% or less than 2%, and they were then given a normal laying diet until 97 weeks of age. Water was available at all times and 15.5 h of constant light was provided daily to all treatments throughout the experiment. Hens given the zinc and the whole-grain barley diets ceased egg production within 1 week and remained out of production for about 10 days. The hens in both of these treatments reached peak egg production (67%, on a hen day basis) 8 weeks after the initiation of treatments, after which they continued to lay at a higher rate than those given iodine, calcium and control treatments. Hens given the diets with either iodine or calcium reached their lowest rate of lay (1.6%) after 15 and 7 days of feeding the two diets respectively. They resumed laying immediately after the resumption of feeding the normal laying diet and reached peak egg production (59%) at 8 and 12 weeks after feeding the iodine and calcium diets respectively. The treated hens laid eggs with higher Haugh units and specific gravity values than those eggs of the controls. The lowest rate of decline in both those traits from the pretreatment values was in the zinc and barley treatments. These treatments also had the lowest percentage of cracked eggs. There was no significant difference among treatments in mean rate of lay, egg weight, or rate of mortality from 73 to 97 weeks of age. The present results suggest that feeding whole-grain barley can be used successfully to extend the productive life of laying hens beyond the first year of egg production if such an extension is desirable in a given economic situation. It is a simpler technique than the conventional method of induced moulting and the method of feeding a high level of zinc.

Descriptors: zinc, iodine, calcium, whole grain, barley, mean lay rate, egg production

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Albuquerque R de (1988). **Effect of sodium chloride, zinc oxide and potassium iodide, compared with feed restriction, on induced molting in laying hens and their productivity.** [Acao do cloreto de sodio, oxido de zinco e iodeto de potassio em comparacao com a restricao alimentar, sobre o descanso forçado em galinhas poedeiras e sua produtividade.] *Thesis - Universidade de Sao Paulo Brazil*, 86 pp.

NAL Call Number: SF494.A43

Departamento de Cricao de Ruminantes e Alimentacao Animal, Faculdade de Medicina Veterinaria e Zootecnia, Universidade de Sao Paulo, Sao Paulo, Brazil.

At 66 weeks old, 128 each of Babcock and Hisex Brown hens, caged singly, were deprived of feed for 11 days or given diets without added NaCl for 42 days or diets with 2% ZnO for 11 days or 0.6852% KI for 42 days. Thereafter all had the same commercial laying diet. Molting was induced by all treatments except NaCl deprivation. Subsequent productivity was significantly higher with feed deprivation and 2% ZnO than with the other treatments. With feed deprivation and 2% ZnO and body weight loss was higher, feed consumption lower and feed conversion better than the other treatments. Egg weight was highest and quality of eggs, measured by Haugh units, and quality of shells was poorest in group 1. Survival rate was not affected by treatment. Results between strains are compared.

Descriptors: molting, restricted feeding, sodium chloride, zinc oxide, potassium iodide, egg quality

Alsobayel AA; Alkhateeb NA (1992). **Effect of force molting induced conventionally or by high dietary aluminum on egg and shell quality of laying hens.** *Asian-Australasian Journal of Animal Sciences* 5(2): 341-347.

King Saud University, Riyadh, Saudi Arabia

NAL Call Number: SF55.A78A7

Descriptors: hens, molting, aluminum, egg quality

Alsobayel AA; Alkhateev NA (1992). **Evaluation of high dietary aluminum as a force-resting agent in laying hens.** *Arab Gulf Journal of Scientific Research* 10(3): 81-92.

Department of Animal Production, College of Agriculture, King Saud University, PO Box 2460, Riyadh 11451, Saudi Arabia.

NAL Call Number: Q1 A65

Laying Saudi Arabian Baladi hens were subjected to 4 dietary treatments: fed to appetite on a commercial control layer diet containing 17% crude protein, 3.6% calcium and 0.343% available phosphorus; fed initially on a commercial force-molting diet, starved for 10 days and then fed for 18 days on cracked maize; and fed for 15 days to appetite on the control diet supplemented at 0.35% with aluminum as Al sulphate or Al chloride. During the molting period hen-day egg production was 45.02, 37.50, 38.32 and 40.66 eggs, respectively. The added Al depressed feed intake and body weight. Concentration of inorganic P in plasma was highest with the control diet and lowest with aluminum chloride; differences between groups were not significant 10 days after the end of dietary treatments.

Descriptors: hen feeding, aluminum, mineral supplements, molting, egg production, poultry, minerals, trace elements, calcium, phosphorus

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Berry WD; Brake J (1987). **Postmolt performance of laying hens molted by high dietary zinc, low dietary sodium, and fasting: egg production and eggshell quality.** *Poultry Science* 66(2): 218-226.

NAL Call Number: 47.8 AM33P

Descriptors: hens, reproductive performance, molt, fasting, zinc, sodium, photoperiod, egg production, egg shell quality

Berry WD; Brake J (1985). **Comparison of parameters associated with molt induced by fasting, zinc, and low dietary sodium in caged layers.** *Poultry Science* 64(11): 2027-2036.

NAL Call Number: 47.8 AM33P

Descriptors: hens, molt, fasting, zinc, sodium, physiological functions, cage rearing

Berry WD; Gildersleeve RP; Brake J (1987). **Characterization of different hematological responses during molts induced by zinc or fasting.** *Poultry Science* 66(11): 1841-1845.
Department of Poultry Science, North Carolina State University, Raleigh, NC 27695-7608.
NAL Call Number: 47.8 AM33P

Single Comb White Leghorn hens were induced to molt by complete fasting for 11 days (FAST) or feeding a layer ration that contained 20,000 ppm zinc as zinc oxide for 11 days (ZINC). In both cases hens lost approximately 30% of their initial body weight. A control (CON) group was maintained. At 4, 8, 12, 18, and 42 days after initiation of the treatments, total erythrocyte numbers (TRBC), percent packed cell volume (PCV), mean corpuscular volume, hemoglobin (Hb), mean corpuscular hemoglobin (MCHb), and mean corpuscular hemoglobin concentration (MCHC) were determined. Erythrocytes were characterized as reticulocytes, intermediate Stage VII erythrocytes, or mature Stage VIII erythrocytes. The FAST hens exhibited significantly increased PCV through 18 days, which was not exhibited by ZINC hens. The FAST treatment increased TRBC on Days 8 and 12 and decreased TRBC on Day 42 while ZINC decreased TRBC on Day 4 and increased TRBC on Day 12. The FAST hens exhibited decreased Hb on Day 42, as reproduction resumed. Both ZINC and FAST hens exhibited decreased MCHb and MCHC on Day 12. Percentages of reticulocytes were decreased at Day 4 by FAST and increased at Days 8 and 18 by ZINC. Stage VII erythrocytes were decreased on Days 4 and 12 in FAST hens whereas ZINC hens exhibited a decrease on Day 4 and an increase on Days 8 and 18. Concomitantly, FAST hens exhibited an increase in Stage VIII erythrocytes on Days 4 and 12, whereas an increase on Day 4 and decreases on Days 8 and 18 were observed in ZINC hens.

Descriptors: Chickens--blood--BL, Fasting, Feathers--physiology--PH, Zinc --pharmacology--PD, Zinc Oxide--pharmacology--PD, Chickens--physiology--PH, Erythrocyte Count--veterinary--VE, Erythrocyte Indices--veterinary--VE, Feathers--drug effects--DE, Hematocrit--veterinary --VE, Hemoglobins--analysis--AN

Bessei W (1978). **Use of a low-sodium diet to induce a laying pause in hens. [Die Anwendung einer natriumarmen Ration zur Steuerung der Legepause bei Legehennen.]** *Archiv fur Geflugelkunde* 42(3): 115-122.

Lehrstuhl fur Kleintierzucht, Univ. Hohenheim, Postfach 106, 7000 Stuttgart 70, German Federal Republic

NAL Call Number: 47.8 AR2

After 12 months of egg production 1600 hens in 2 groups were fed on a low-Na diet for 3 or 4 weeks. Subsequent production and egg quality were recorded for 8 periods of 4 weeks.

Within 3 weeks egg production decreased to below 3%. Both groups reached 50% hen-day production at the 11th week and rose to a peak of 82 to 83%. When the low-Na diet was introduced, egg weight decreased and then increased to 67 g when the hens were transferred to the normal diet. Egg shell strength was improved until the 16th week of trial and then decreased. Egg shell deformation, percentage egg shell and albumen index also improved in the first part of the second year. Yolk colour decreased after the treatment and reached normal values after 20 weeks. During feeding on the low-Na diet mortality increased but returned to normal after changing to the complete diet. There was no significant difference between groups for egg production, egg weight, albumen index or yolk colour. The egg shell quality was better and the mortality higher in the group on the low-Na diet for 4 weeks. Descriptors: egg production, feeds, sodium, molt, induction, laying performance, nutrition Copyright© 2002, CAB International

Bessei W; Lantzsch HJ (1980). **Induction of pauses in laying with diets rich in zinc.** [Untersuchungen zur Einleitung von Legepausen mit zinkreichen Rationen.]. *Archiv für Geflügelkunde* 44(3): 133-140.
Lehrstuhl Kleintierzucht, Garbenstr. 17, 7000 Stuttgart 70 - Hohenheim, German Federal Republic.

NAL Call Number: 47.8 AR2

To investigate the effect of zinc concentration in the diet of laying hens on egg production and egg Zn levels, groups of 8 White Leghorn Hybrid (LSL) laying hens were given diets with Zn 5000, 10 000, 15 000 or 20 000 mg/kg feed for periods of 2, 4, 6 or 8 days, following which normal laying diets were given. Each of the 16 treatment combinations was replicated 8 times, and the trials were conducted for 4 laying periods of 4 weeks. Egg production during administration of the Zn-rich diets decreased with increasing Zn concentration and duration of treatment. Treatments producing the most marked reduction in output were those which gave the best output during the third and fourth laying periods. During these periods there were no treatment-related differences in the consumption of the standard diet. The daily intake of Zn decreased in the groups given the highest level of dietary Zn for the longest period, and efficiency of feed conversion was increased in the groups given Zn-rich diets for periods greater than 2 days. Zn in eggs showed a slight increase with duration of treatment but no apparent effect due to Zn concentration and even the highest level recorded (54 mg/kg) would be harmless to humans. Body Zn levels were estimated in other birds fed similarly. Concentration of Zn or duration of treatment had no significant effect on levels of Zn.

Descriptors: zinc, hen feeding, hens, egg production

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Brake J (1993). **Recent advances in induced molting.** *Poultry Science* 72(5): 929-931.

North Carolina State University, Raleigh, NC

NAL Call Number: 47.8 AM33P

Molt induction methods that produce a complete cessation of lay, reproductive involution for several days, and loss of nearly 50% of the primary feathers are the most successful. Feed

deprivation and high levels of dietary zinc have proven to be the most consistent methods available. Calcium appears to play a pivotal role in molt induction as calcium carbonate feeding prolongs ovulation during the initial stages of an induced molt and dietary zinc has been shown to interfere with calcium-related metabolic activities at the level of the ovary. The primary site of action of feed deprivation appears to be at the level of the hypothalamic-hypophyseal axis, where calcium is involved in many endocrine pathways. The physiological basis of postmolt rejuvenation has been related to the extent of ovarian and oviductal involution. Evidence suggests that restructuring of receptor or membrane functions in the oviduct is the basis for rejuvenation. A body weight loss of about 30% appears to be necessary for appropriate restructuring of the shell gland.

Descriptors: hens, molting, induction, zinc, calcium, weight losses, fasting, feathers, lh, ovaries, suppression, c-amp, oviducts, epithelium

Breeding SW; Brake J; Garlich JD; Johnson AL (1992). **Molt induced by dietary zinc in a low-calcium diet.** *Poultry Science* 71(1): 168-180.

North Carolina State University, Raleigh, NC

NAL Call Number: 47.8 AM33P

Three experiments were designed to test the hypothesis that zinc has a specific effect independent of anorexia during induction of molt. In Experiment 1, hens were fed a low-calcium (.08%) basal molt diet to which was added 0, 110, 620, or 1,120 mg/kg (ppm) zinc as zinc sulfate heptahydrate ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$) for 7 days and 0, 1,400, 2,800, or 4,200 ppm zinc, respectively, for the following 14 days. In Experiment 2, hens were provided ad libitum access to the low-calcium basal molt diet with 2,800 ppm added zinc for 14 days during which a paired control hen received a similar amount of the low-calcium basal molt diet. In Experiment 3, hens were fed the low-calcium basal molt diet on a restricted basis amended with either 0 or 2,800 ppm zinc on a restricted basis for 10 days. In Experiment 1, all hens that consumed zinc had significantly fewer days to last oviposition as compared with control hens, and this occurred without significant differences in body weight or feed consumption for the lowest zinc group. When compared with the control group, higher levels of zinc did decrease body weight and feed consumption. In Experiment 2, the hens consuming the diet with 2,800 ppm zinc (Zn2800) reached last oviposition significantly sooner than control hens, although the Zn2800 hens actually consumed more feed. In Experiment 3, the Zn2800 hens lost more body weight than control hens due partially to earlier reproductive tract regression. Serum luteinizing hormone was increased in the Zn2800 hens. In the absence of supplemental dietary calcium, dietary zinc in moderate concentrations (less than or equal to 52,800 ppm) has a specific suppressing effect on reproduction independent of anorexia. Descriptors: hens, zinc, feed intake, molt, follicles, calcium, mineral deficiencies, body weight, egg production, ovaries, weight, oviducts

Breeding SW; Berry WD; Brake J (1992). **Research note: maintenance of duodenum weight during a molt induced by dietary zinc in a low-calcium diet.** *Poultry Science* 71(8): 1408-1411.

North Carolina State University, Raleigh, NC

NAL Call Number: 47.8 AM33P

The duodenal loop was excised from hens that had been induced to molt by a low-calcium diet containing 2,800 ppm zinc in the form of zinc sulfate heptahydrate. This was compared to that of hens pair-fed a layer diet. In Experiment 1, hens exhibited an increased duodenum weight after receiving the zinc diet for 14 days but no differences remained 14 days later. In Experiment 2, increased duodenum weight was noted after 4 days on the zinc diet and this persisted through 10 days. This greater tissue weight was observed whether expressed on a wet or dry weight basis. Thus, there was a persistency of tissue mass. The duodenum does not regress during a zinc-induced molt as it does during a fast-induced molt.

Descriptors: hens, dietary minerals, mineral deficiencies, calcium, zinc, molt, duodenum, weight, induced molt

Cunningham DL; McCormick CC (1985). **A multicycle comparison of dietary zinc and feed removal molting procedures: production and income performance.** *Poultry Science* 64(2): 253-260.

Dep. Of Poultry And Avian Sciences, Cornell University, Ithaca, NY 14853.

NAL Call Number: 47.8 AM33P

Two experiments were conducted to evaluate performance and income factors associated with ZnO and feed removal multicycle molt programs. Experiment 1 compared 2 strains of commercial White Leghorn layers molted with 20,000 ppm ZnO in the feed for 4 days with a feed removal program of 10 days followed by 10 days of cracked corn. Experiment 2 compared a single strain of White Leghorn layers molted with 20,000 ppm ZnO with feed removal for 4 and 10 days. Body weight loss during molt averaged 25-30% for the longer duration molt programs compared to 14-16% for the short duration programs. Differences on body weight loss between ZnO and feed removal programs employing the same durations of treatment were not significant ($P < 0.05$). No significant ($P < 0.05$) differences were observed between ZnO and feed removal programs for hen-housed egg production, days to reduce egg production to 0%, feed usage or mortality rates. Differences in egg size and egg grade distributions were observed among molting programs and strains. Incomes over pullet and feed costs for the molted flocks were greatest during the 1st molt cycle. Incomes over pullet and feed cost during the 2nd molt cycle were generally negative. The longer duration molt programs resulted in total incomes over feed and pullet costs averaging 5.0.cents./doz more than the shorter 4 day duration programs. Duration of molt-inducing periods had greater effects on performance and income results than did the method used to induce rest.

Descriptors: white leghorn chicken, corn, metabolic-drug, egg production, pharmacodynamics

Dalin VN (1977). **Development of a method for moult induction in intensively reared hens.**

[Razrabotka metodiki provedeniya prinuditel'noi linki kur v usloviyakh ikh itensivnogo soderzhaniya.] *Izvestiya Timiryazevskoi Sel'skokhozyaistvennoi Akademii* (No. 6): 158-169, 228.

The method developed involves (1) the withdrawal of food for 4 days, and its reintroduction in a manner depending on the initial stage of moulting, (2) the use of low-calcium diet, and

(3) 2 periods (4 days and 3 days resp.) of complete darkness. For 3 groups, each of 8900 layers, induced to moult using this method, induced to moult by the previously used Canadian method, and not induced to moult, egg production per hen in 9 mth averaged 108.0, 126.0 and 106.4 resp.

Descriptors: moult, induction, methodology, egg production

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Daniel M; Balnave DA (1980). **A comparison of methods of inducing a pause in egg production in crossbred layers.** *Australian Journal of Agricultural Research* 31(6): 1153-1161.

Dep. Animal Husbandry, Univ. Sydney, Werombi Road, Camden, NSW 2570, Australia

NAL Call Number: 23 Au783

In experiment 1, 20 replicates of 6 White Leghorn X Australorp laying hens, aged 84 weeks, were allocated to each of 4 treatments. The first involved withholding water and feed for 2 and 7 days, respectively; thereafter 50 g cracked wheat daily was given to each bird for 2 weeks followed by free access to a commercial laying diet. The second group was offered a diet containing zinc 18.7 g/kg for 7 days and were then treated as group 1. The third group was given a diet containing calcium 0.9 g/kg for 4 weeks and then returned to the commercial laying hen diet. The fourth group was allowed free access to cracked wheat for 2 weeks then 50 g wheat/bird daily for 2 weeks followed by the commercial diet. Birds on treatments 2 to 4 consumed 12, 114.1 and 98 g daily, respectively, during the first 7 days compared to 136.2 g for all birds at the start of the trial. After returning to the commercial diet, birds fed on treatments 1 to 4 ate 129.1, 130.1, 121.1 and 127.1 g daily, respectively, between 89 and 104 weeks. Mean bodyweights at 104 weeks were 2.081, 2.041, 2.126 and 2.008 kg compared to a mean weight of 2.110 kg at 84 weeks. Egg production for these birds was 65.55, 63.34, 48.07 and 55.24 eggs/100 birds. In experiment 2 each of 4 commercial laying diets was given to 3 replicates of 4 White Leghorn X Australorp hens, aged 84 weeks. The diets were supplemented with Zn 2.2, 4.1, 7.5 and 18.7 g/kg as zinc oxide. After 1 week, birds on diets 3 and 4 were given 50 g cracked wheat daily for 2 weeks before being allowed free access to the unsupplemented layer's diet. Birds on diets 1 and 2 continued on these diets for 3 weeks when they were returned to the unsupplemented layer's diet. Birds on diet 4 ceased lay by day 7 and those on diet 3 by day 8. Birds on diets 1 and 2 had their rates of lay reduced to 44% and 22%, respectively by the end of week 3, compared to a rate of lay of 50% at the start of the trial. There was no significant difference among treatments in mean food intake, daily egg production, mean egg weight or Haugh unit value following the return to the commercial diet.

Descriptors: egg production, molting, molt, induction, methodology

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Douglas CR; Harms RH; Wilson HR (1972). **The use of extremely low dietary calcium to alter the production pattern of laying hens.** *Poultry Science* 51(6): 2015-2020.

Dep. Poultry Science, Florida Agricultural Experiment Station, Gainesville, Fla. 32601.

NAL Call Number: 47.8 AM33P

Hens that had been laying for 6 months were individually caged and given for 16 weeks diets

based on maize and soya bean meal. The control mixture contained 3% Ca and 0.7% P, other groups were given 0.09% Ca and 0.32% P for 14 or 42 days and after that the control diet. Many hens given the low-Ca diet were unable to stand after 3 days but soon recovered. By 14 days egg production had fallen from 65 to 12%. Four weeks later, after returning to the control diet, egg production was similar to that of control birds. Egg production of the 42 days depleted group fell to 2% by 4 weeks. After return to the control diet, it increased only to about 40%. The sp. gr. of eggs was not affected by any treatment. Mortality was 8.6% for controls, 28.6% for the low-Ca groups. Hens in production for 10 months were given for 20 weeks the same diets as before and a further group was given the low-Ca diet for the whole period. After 2 weeks egg production of all low-Ca groups had fallen to about 3%. After return to the control diet both groups exceeded control group egg production 10%. Birds continuously given the low-Ca diet had a mean egg production of about 6%. Egg shell thickness was significantly greater at 60 days in groups depleted for 42 days in controls. Bodyweight of birds continuously given the low-Ca diet was significantly lower than that of all other groups; the breaking strength of the tibia and bone ash were significantly lower. The possibility is considered that suspension of laying induced by a short period on low-Ca diet might replace forced molting.

Descriptors: poultry, feeding, calcium, intake, egg production, hens

Filipovic Z; Stevancevic M (1999). **Application of ZnO in diet for induction of molting in SSL-hybrid hens on a farm "Koka-Promet" in Budva, Yugoslavia.** [Primjena ZnO u ishrani za izazivanje prinudnog mitarenja kod kokica SSL-hibrida na farmi "Koka-promet" u Budvi.] *Zivinarstvo* 34(10): 9-12.

Javna veterinarska ustanova Republike Crne Gore, Podgorica, Yugoslavia.

The use of zinc oxide (ZnO) for induction of molting was evaluated on a farm of 10 000 of SSL-hybrid hens in Budva, Yugoslavia, in April 1997. ZnO was added to the diet at 15 kg/600 kg of diet at the end of technological laying period at 73 weeks of age. molting was completed within 8 to 10 days and new feathers appear 28 days after molting. Laying period was extended by 10 months after induction of molting, at which time egg production was 53%. It is concluded that ZnO at 25 000 ppm/1000 kg of feed has no toxic effect. Total mortality during 10 months of extended laying period was 7%.

Descriptors: molting, poultry, zinc oxide, diets, mortality, egg production, hens

Franchini A; Meluzzi A; Urrai G; Bertuzzi S; Giordani G (1986). **Induction of moulting in laying hens. 2. Effect of starvation and diets deficient in calcium and sodium.** [Induzione della muta nelle galline ovaiole. 2. Effetti del digiuno e di diete calcio e sodio carenti.] *Avicoltura* 55(3): 14-17.

Istituto Zooculture, Facolta di Agraria, Univ. degli Studi, Bologna, Italy

NAL Call Number: 47.8 R523

Moulting was induced in 216 Warren laying hens, 74 weeks old, by starvation, a diet with 0.04% calcium or a diet with 0.02% sodium. Egg laying ceased after 8 days of starvation and decreased to 5 and 6% of normal after 15 and 28 days on the diets deficient in Ca or Na. Weight loss was 15.89, 12.29 and 10.71 g, respectively. Resumption of laying after feeding to

appetite took longer but performance during the 2nd production cycle was best in starved hens. Egg weight and shell density were unaffected by molting method. Albumen quality was improved by starvation.

Descriptors: moult, starvation, hens, calcium, deficiency, sodium

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Francis DW; Roberson RH (1980). **Chemical constituents of blood from chickens subjected to molt.** *Poultry Science* 59 (7): 1610.

Dep. Animal and Range Sciences, New Mexico State Univ., Las Cruces, NM 88003, USA.

NAL Call Number: 47.8 AM33P

Laying hens, 3/cage, were bled before moult, after moult induced by deprivation of feed or giving zinc, and 3 times after return to lay. Inorganic phosphorus, potassium and albumin were significantly different between controls and treated hens. Means for lactic dehydrogenase and serum glutamic oxaloacetic transaminase were greater in the treated groups than in controls. Thirteen blood constituents were significantly different for the treatment X period interaction. The largest difference, which occurred between the control and the 2 treated groups after moulting, was associated with weight loss and cessation of egg production.

Descriptors: blood composition, moulting

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Gascon FM; Piquer JG; Vinas L (1985). **Comparative study of two methods of forced moult in layers. II. [Estudio comparativo de dos metodos de muda forzada en ponedoras. II.]**

Medicina Veterinaria 2(9): 413-421.

Dep. Path., Fac. Vet., Zaragoza, Spain.

Comparison of serum corticosterone, heterophil percentage and relative adrenal weight in two groups of each of 60 layers undergoing the feed and water restriction method or the zinc oxide method of forced moult revealed significant increases in all these values with the first method, but not with the zinc oxide method.

Descriptors: hens, restricted feeding, zinc, moulting, stress, moult

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Gascon FM; Piquer JG (1985). **Comparative study in two methods of forced molting in laying hens, 3: Effect on different protein fractions and total serum proteins. [Estudio comparativo de dos metodos de muda forzada en ponedoras, 3: Efecto sobre las diferentes fracciones proteicas y proteinas totales sericas].** *Medicina Veterinaria* 2(10): 487-492.

Zaragoza Univ., Spain, Facultad de Veterinaria

The serum protein fractions and total protein in 180 White Leghorn hens of 44 weeks of lay are studied during a forced molt using two different methods: feed and water restriction and zinc oxide. The hiprotaenemia is very significant ($P < 0.01$) in both molting groups but there are no differences between them, except the decrease of gamma-globulins what is higher in the feed and water restriction group. In the other serum proteic fractions no differences have

been observed between the three groups. According to the results observed the zinc oxide method seems better than the feed and water restriction for the practice of forced molt. Descriptors: layer chickens, molting, globulins, albumins, blood protein disorders, water deprivation, oxides, zinc, animals, biological rhythms, birds, blood composition, blood disorders, blood proteins, chickens, composition, disorders, domestic animals, domesticated birds, elements, galliformes, heavy metals, industrial pollutants, injurious factors, inorganic compounds, metals, nutrition, nutritional phenomena, organic compounds, pollutants, poultry, proteins, time, timing, vertebrates

Goodman BL; Norton RA; Diambra OH (1986). **Zinc oxide to induce molt in layers.**

Poultry Science 65(11): 2008-2014.

NAL Call Number: 47.8 AM33P

The effects of the addition of Zn as ZnO to diets to induce molt were evaluated against a fasted control. Experiment 1 involved 315 Leghorn hens, 15 months old, randomly distributed among five treatments, each replicated seven times with 9 hens per replicate. Hens fasted for 10 days were compared with hens fed diets to which ZnO was added at 10,000, 5,000, or 2,500 ppm for 7, 14, or 21 days. No significant differences were observed among treatments for days to return to 50% production, hen-day and hen-housed production, egg weight, grams egg per hen-day, grams of feed per gram egg, mortality, or Haugh units during the 22-week experimental period. Experiment 2 involved 420 Leghorn hens, 18 months old, randomly distributed among five treatments, each replicated seven times with 12 hens per replicate. Treatments involved fasting for 10 days or feeding diets with 10,000, 5,000, or 2,500 ppm ZnO fed for 7, 14, or 21 days. Hens fasted and hens fed diets with 10,000 ppm ZnO at the start of the experiment ceased production in significantly less time (4.6 to 6 days) than hens fed 5,000 ppm ZnO (14.3 to 14.9 days); however, days to return to 50% production from the start of the experiment did not differ among treatments. Feed consumption and feed cost per hen day during molt were lowest (P less than .05) in the fasted hens.

Descriptors: physiology--PH; Feathers--drug effects--DE; Zinc--pharmacology --PD; Zinc Oxide--pharmacology--PD ; Diet CAS Registry No.: 1314-13-2 (Zinc Oxide); 7440-66-6 (Zinc)

Harms RH (1991). **Effect of removing salt, sodium, or chloride from the diet of commercial layers.** *Poultry Science* 70(2): 333-336.

University of Florida, Gainesville, FL

NAL Call Number: 47.8 AM33P

Two experiments were conducted with Hy-Line W-36 hens. The hens were 45 and 65 wk old at the start of Experiment 1 and 2, respectively. A corn-soybean meal basal diet was used. Four diets were fed for 19 days: 1) control; 2) no added NaCl; 3) no added NaCl with Na supplied as NaHCO₃; and 4) no added Na with Cl supplied as CaCl₂. All hens were fed the control diet from Day 20 to Day 84. Hens fed a diet without NaCl reached zero production in 9.8 and 13.3 days in Experiments 1 and 2, respectively. Hens fed the diet without Na reached zero production in 10.3 and 13.1 days in Experiments 1 and 2, respectively. Only a few of the hens fed the diets with no Cl reached zero production. Time required for all hens to return to

production after returning to control diets were 16.0, 15.7, and 6.0 days for hens receiving no added NaCl, Na, or Cl, respectively in Experiment 1, and 13.2, 15.0, and .6 days in Experiment 2. Molting occurred in 92.7, 77.8, and 24.2% of the hens receiving the no NaCl, Na or Cl, respectively, in Experiment 1, and 80.0, 72.5, 30% in Experiment 2. Mortality rates were 7.5, 12.5, 20.0, and 5.0% for the hens receiving diets with no NaCl, Na, Cl or control, respectively, in Experiment 1, and 2.5, 10.0, 20.0, and 0% in Experiment 2.

Descriptors: hens, sodium chloride, egg production, molt, feed intake, feathers, mortality, mineral deficiencies, egg weight, specific gravity ;

Harms RH (1983). **Benefits of low sodium in the diets of laying hens during the period prior to forced rest.** *Poultry Science* 62(6): 1107-1109.

NAL Call Number: 47.8 AM33P

Hassan MSH (1996). **Physiological changes in laying fowl during forced molting.** *Thesis Degree: Thesis (M.Sc. in Poultry Production)* Cairo Univ. (Egypt). Faculty of Agriculture, 156 p.

Availability: Library, of Faculty of Agriculture, Cairo Univ., Egypt

Descriptors in English: layer chickens, forced molting, zinc, feed additives, laying performance, animal performance, blood composition, additives, animal husbandry methods, animal performance, birds, blood, chickens, domestic animals, domesticated birds, elements, galliformes, heavy metals, livestock, metallic elements, poultry

Hussein AS; Cantor AH; Johnson TH (1989). **Comparison of the use of dietary aluminum with the use of feed restriction for force-molting laying hens.** *Poultry Science* 68(7): 891-896.

University of Kentucky, Lexington, KY

NAL Call Number: 47.8 AM33P

Descriptors: hens, molting, aluminum sulfate, restricted feeding, egg production

Johnson AL; Brake J (1992). **Zinc-induced molt: evidence for a direct inhibitory effect of granulosa cell steroidogenesis.** *Poultry Science* 71(1): 161-167.

Department of Animal Sciences, Rutgers, State University of New Jersey, New Brunswick, New Jersey 08903, USA.

NAL Call Number: 47.8 AM33P

Results from previous studies indicate that the use of dietary zinc may provide an effective means to initiate an induced molt in laying hens. Although much evidence indicates that high concentrations of zinc (10 000 to 20 000 ppm) cause the cessation of lay primarily by reducing feed intake, recent data suggest that lower concentrations (2800 ppm) in a calcium-deficient diet may have a direct action on the ovary. Therefore, in a series of in vitro studies it was evaluated whether zinc can affect granulosa cell progesterone production. Incubation of granulosa cells from the largest preovulatory (F1) follicle with Zn as zinc sulfate (0.1 to 10 micro M) had no effect on basal progesterone production. By contrast, ovine LH-stimulated progesterone production was inhibited ($P < 0.05$) in a dose-related fashion by Zn in both the sulfate and acetate forms (1 to 10 micro M). Furthermore, Zn attenuated ovine LH- and forskolin-induced cyclic adenosine monophosphate (cAMP)

formation, and inhibited 8-bromo-cAMP- and calcium ionophore (A23187)-induced progesterone production. Such results indicate both pre- and post-cAMP sites of action for the inhibitory actions of Zn on progesterone production in F1 granulosa cells. Finally, ovine FSH-stimulated cAMP accumulation and progesterone production in granulosa cells collected from 9- to 12-mm follicles (a stage of development representing the early, rapid growth phase) were suppressed ($P < 0.05$) by co-incubation of cells with Zn. From these data, it can be concluded that the effectiveness of Zn to induce the cessation of lay is due, at least in part, to a direct inhibitory action on ovarian granulosa cell function both in differentiating and in preovulatory follicles.

Descriptors: steroid metabolism, granulosa cells, zinc, intake, hens, molting, molt, induction, nutrition, ovaries, steroidogenesis, in vitro, minerals

Kilic A; Kor I (1983). **Effects of induction of moulting by zinc oxide in laying hens. [Yumurta tavukculugunda cinko oksit ile tuy dokumune zorlanimin etkinlikleri uzerine arastirmalar.]** *Ege Universitesi Ziraat Fakultesi Dergisi* 20(3): 15-28.

For 4 days groups of 6500 Golden Comet laying hens 76 weeks old were given a layer feed alone or with zinc oxide 25 g/kg. Zn increased egg yield and profitability but decreased feed intake and liveweight which however improved with time. Induction of moulting by Zn supplement was considered better than conventional methods.

Descriptors: hen feeding, zinc, supplements, egg production, moult
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Kuchinski KK; Harms RH (1994). **Signs observed in commercial laying hens fed a low dietary salt level.** *The Journal of Applied Poultry Research*. 3(1): 93-99.

University of Florida, Gainesville, FL.

NAL Call Number: SF481.J68

Descriptors: hens, dietary minerals, sodium chloride, mineral deficiencies, laying performance, molting, follicles, feed intake, egg weight, specific gravity, sodium-restricted diets, duration

Lukarev T; Dodovski M; Prodanov R (1988). **The use of zinc oxide in feed for the induction of moult in light egg-laying hybrids. [Primena cink oksida u ishrani za izazivanje prinudnog mitarenja kod lakih hibrida.]** *Peradarstvo* 23(5-6): 139-145.

Veterinary Institute, Skopje, Yugoslavia

NAL Call Number: SF481 P4

Moult was induced in Hisex hens aged 79, 80, 83 or 85 wk (3265, 8000, 804 and 480 females per group resp.) using supplementation of feed with zinc oxide (2.5 kg/100 kg feed) and shortening daylight to 12 h daily. Egg production decreased to 50% within 2 days of the beginning of treatment, and to 0 on the 7th day; the pattern was similar for all age groups. Feed consumption, and consequently body weight, also decreased: on the 7th day of treatment, feed consumption was only 20% of that before treatment, and body weight decreased from 1920-2030 to 1704-1807 g during that period. moult began on the 10th-12th

day. Feed intake increased to normal within a week from the end of treatment, and egg production resumed during the 2nd week.

Descriptors: moult, induction, nutrition, zinc oxide, zinc, hens, poultry

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Marafi A; Goodman BL; Gholson JT (1981). **Recycling methods in adult hens (Forced molt, byfeed and water removal, nicabozin, low calcium, protein, sodium).** *Ag Review Southern Illinois University, School of Agriculture* p. AN15-AN17.
NAL Call Number: S537.S5S6

Mather FB; Wilson HR; Ingram DR (1982). **Performance and oviductal histology of hens as influenced by low calcium and-or low sodium diets during a force molt.** *Poultry Science* 61(7): 1385-1386.
NAL Call Number: 47.8 AM33P
Descriptors: hen, premature, egg production, magnum, atrophy, isthmus

McCormick CC; Cunningham DL (1987). **Performance and physiological profiles of high dietary zinc and fasting as methods of inducing a forced rest: a direct comparison.** *Poultry Science* 66(6): 1007-1013.
NAL Call Number: 47.8 AM33P
Descriptors: hen feeding, fasting, zinc, body weight, egg production, ovaries (animal), oviducts, rest

McCormick CC; Cunningham DL (1984). **Forced resting by high dietary zinc: tissue zinc accumulation and reproductive organ weight changes (Laying hens).** *Poultry Science* 63(6): 1207-1212.

NAL Call Number: 47.8 AM33P

An experiment was conducted to investigate the effects of high dietary zinc, as a means of inducing a forced-rest, on selected organ accumulation of zinc and reproductive function in terms of ovary and oviduct weight in the laying hen. Single Comb White Leghorn hens laying approximately at 60% production were fed either 10,000 ppm zinc as zinc oxide (10 Zn) or 20,000 ppm zinc (20 Zn) for a period of 4 days. At the initiation of the experiment (Day 0), five hens were killed and organs obtained for analysis. On 4, 10, 16, and 22 days afterward, similar samples were obtained from 5 hens per treatment. Ovary and oviduct weights were determined and zinc analysis performed on the latter as well as liver, kidney, and pancreas. The brief 4-day feeding of either high zinc diet caused a marked 80% reduction in ovary weight by Day 10. The oviduct, although less affected, was still reduced approximately 60% in weight after feeding either 10 Zn or 20 Zn for 4 days. The oviduct exhibited a statistically significant elevation in zinc concentration on Day 4 but was normal by Day 10 (6 days following the refeeding of a normal diet) and not different between treatments. There was extensive accumulation of zinc in kidney, liver, and especially pancreas after 4 days of feeding either 10 Zn or 20 Zn. The level of dietary zinc had no effect on the extent of accumulation in any tissue. The depletion of tissue zinc roughly corresponded to the

magnitude of increase in the concentration of zinc observed at Day 4. Possible ramifications of the dramatic increase observed in pancreatic zinc were discussed. We concluded that feeding either 10 Zn or 20 Zn as a means of inducing a forced rest effects a marked and rapid reduction in ovary and oviduct weight as well as an extensive increase in renal, hepatic, and especially pancreatic zinc.

Descriptors: *Chickens--metabolism--ME; *Ovary--anatomy and histology--AH; *Oviducts--anatomy and histology--AH; *Zinc--administration and dosage--AD; *Zinc--metabolism--ME; *Zinc Oxide--administration and dosage--AD ; Chickens--anatomy and histology--AH; Diet; Kidney--metabolism--ME; Liver --metabolism--ME; Organ Specificity; Organ Weight; Pancreas--metabolism--ME

McCormick CC; Cunningham DL (1984). **High dietary zinc and fasting as methods of forced resting: a performance comparison (Hens).** *Poultry Science* 63(6): 1201-1206.
NAL: 47.8 AM33P

McCormick CC; Cunningham DL (1982). **Forced molting of laying hens by zinc toxicity.** *Proceedings - Cornell Nutrition Conference for Feed Manufacturers*, p. 17-24.
NAL Call Number: 389.79 C81

A study was conducted to compare fasting and high dietary zinc as procedures to induce a forced rest of laying hens. Five to six replicates (25 hens each) of Single Comb White Leghorn hens laying approximately 60% were fasted for 10 days (fasted) or fed either 10,000 ppm zinc (10 Zn) or 20,000 ppm zinc (20 Zn) for a period of 4 days. A fourth treatment consisted of feeding 20,000 ppm zinc for 8 days (20 Zn-8). During the rest-inducing period, hens consumed little of either high zinc diet. Four-day intake by 20 Zn hens averaged 17.6 +/- .2 g/hen/day compared to 32.6 +/- 1.5 g/hen/day (means +/- SEM) for 10 Zn hens. Those fed 20 Zn-8 consumed the least amount, 12.6 +/- .2 g/hen/day during the 8 days of high zinc feeding. Body weight loss of hens in this last group was comparable to hens fasted for 10 days (fasted), i.e., 24.6 +/- .3% vs. 27.6 +/- .4%. Weight loss of hens in the remaining two groups reflected, to some extent, differences in feed consumption. The 20 Zn hens lost significantly more body weight during the 4-day period when compared with 10 Zn hens (16.2 +/- .4% vs. 11.9 +/- .5%). Each treatment resulted in a sharp drop in egg production. By the 5th day, fasted, 20 Zn, and 20 Zn-8 hens had ceased producing eggs. Egg production by 10 Zn hens declined at a slightly slower rate. There were considerable differences in post-rest egg production among the various treatments.(ABSTRACT TRUNCATED AT 250 WORDS)

Descriptors: *Chickens--physiology--PH; *Fasting; *Oviposition; *Zinc--administration and dosage--AD; *Zinc Oxide--administration and dosage--AD ; Body Weight; Diet; Time Factors

Meluzzi A; Franchini A; Giordani G; Bertuzzi S (1986). **Induction of moult in laying hens. 1. Effects of fasting and of zinc oxide. [Induzione della muta nelle galline ovaiole. 1. Effetti del digiuno e dell'ossido di zinco.]** *Zootecnica e Nutrizione Animale* 12(6): 465-472.
Istituto di Zooculture, Via San Giacomo 9, 40126 Bologna, Italy.

NAL Call Number: SF1 Z6

360 Warren layers, at 70 wk of age and 66% lay, were subjected to the following treatments: (1) addition of 2.5% zinc oxide to the diet for 15 days; (2) fasted for 15 days; (3) addition of 1.1% zinc oxide to the diet for 8 days, followed by 1.5% for 7 days; (4) addition of 2.5% zinc oxide to the diet for 8 days; (5) fasted for 8 days. In the 5 groups resp., zero egg production was reached in 6, 6, 9, 6 and 5 days, and 30% production in the next cycle after 56, 56, 36, 22 and 22 days. Egg production in the 2nd cycle was 65.3, 65.7, 60.2, 56.4 and 62.0% resp., and food consumed per kg eggs 3.06, 3.02, 3.32, 3.42 and 3.09 kg (both $P < 0.01$). Egg weight in the 2nd cycle averaged 67.04, 68.20, 68.06, 67.71 and 68.12 g resp. ($P < 0.05$), Haugh units 74.59, 73.55, 73.67, 73.64 and 71.35% ($P < 0.01$), and egg shell thickness 347.2, 352.0, 352.7, 349.9 and 348.6 micro m ($P < 0.01$).

Descriptors: laying performance, moult, zinc, hens, starvation, egg production

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Naber EC (1983). **Use of low sodium diets and low sodium-low protein diets for recycling of laying hens fed for intervals of 4, 6 or 8 weeks in a low light environment.** *Proceedings of the Maryland Nutrition Conference for Feed Manufacturers*, p.7-12.

Dep. Poultry Science, Ohio State Univ., Ohio Agricultural Research and Development Center, Columbus, Ohio 43210, USA.

NAL Call Number: 389.9 UN342

From results of an experiment with 1200 Hy-Line W-36 laying hens initially 70 weeks old, it was concluded that low-sodium diets can be used to prepare hens for a second period of egg production with results comparable to those obtained by forced moulting. The low-Na diet is easy to administer and avoids criticisms from people concerned with animal welfare.

However, this method can be used only when low-Na drinking water is available and the Na content of the diet can be reduced to 0.05% or less. Results were better with a diet low in Na only than with a diet low in Na and protein. Maximum egg production response occurred with diets used for 6 weeks and was not further improved by an 8-week feeding period. 2 ref.

Descriptors: sodium, intake, hen feeding, egg production, protein intake

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Naber EC; Latshaw JD; Marsh GA (1980). **Use of low sodium diets for recycling of laying hens.** *Poultry Science* 59(7): 1643.

Dep. Poultry Science, Ohio State Univ., Columbus, OH 43210, USA.

NAL Call Number: 47.8 AM33P

Two trials were to study the effect of low-sodium diets on recycling of hens for subsequent reproductive performance. In the first trial the low-Na diets, with or without KCl supplements, were tested. The last egg was laid 11 to 15 days following dietary treatment. For the 6-week period on the experimental diets, feed intake was reduced by 50 or 60%, bodyweight was reduced by 300 g, and 97% of the hens were in an active molt. Potassium supplements did not change the effect of the low-Na diet. In the second trial, both a low-Na and a low Na- low-protein diet were tested in a 6 or 13h daylight environment and compared

to a conventional forced moulting procedure. Both diets stopped egg production, induced moult, reduced bodyweight, and limited feed intake in a similar manner. The 6h daylight accentuated these effects when compared to the 13h daylight. During 32 weeks following treatment, egg production and egg specific gravity were significantly increased by use of the low-Na diet, the low Na-low protein diet, or the conventional forced moulting procedure over that of non-recycled controls. Egg weight and albumen thickness were not affected by the treatment.

Descriptors: sodium, hen feeding

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Naber EC; Latshaw JD; Marsh GA (1984). **Effectiveness of low sodium diets for recycling of egg production type hens.** *Poultry Science* 63(12): 2419-2429.

Dep. Poultry Science, Ohio State Univ., Columbus, OH 43210, USA

NAL Call Number: 47.8 AM33P

Egg type hens were recycled by the use of low sodium diet treatments compared to a conventional forced-molt procedure and an unrecycled control. Use of a low sodium diet containing .02 to .06% sodium for 6 weeks with reduction in daily photoperiod resulted in improvements in egg production, egg specific gravity, and albumen thickness similar to those of a forced-molt group in three separate experiments. Egg production was increased 11 to 13%, egg specific gravity was increased by .002 to .004, and albumen thickness was increased by 2 to 8 Haugh units over the 32-week post-treatment period for both treatments. Hens fed the low sodium diet for 3.5 or 4 weeks did not respond as favorably as hens fed this diet for 6 weeks. Eight weeks on the low sodium diet did not further improve performance. Results comparable to the forced-molt procedure were achieved with a decline in egg production at .03 to .07% sodium in the diet, a decline in feed intake at .03 to .07% sodium, a loss in body weight at .03 to .10% sodium, and an increase in molt score at .03 to .11% sodium during the experimental period. During the post-treatment period, results comparable to the forced-molt procedure were obtained for egg production increase at .03 to .08% sodium, for egg specific gravity increase at .03 to .12% sodium, and for egg albumen thickness increase at .03 to .12% dietary sodium. Mortality was unchanged.

Descriptors: Animal Feed, Chickens--physiology--PH, Diet, Sodium-Restricted, Oviposition , Body Weight, Dietary Proteins--administration and dosage--AD

Nesbeth WG; Douglas CR; Harms RH (1976). **The potential use of dietary salt deficiency for the force resting of laying hens.** *Poultry Science* 55(6): 2375-2379.

Dep. Poultry Science, Florida Agricultural Experiment Station, Gainesville, Fla. 32611

NAL Call Number: 47.8 AM33P

Two experiments with a total of 240 laying hens caged individually were to evaluate dietary salt deficiency as a tool for the forced resting of laying hens. The control group had a maize and soya diet with 0.25% salt added. Another group had a maize and soya diet with no added salt for 6 weeks then returned to the control diet. The third group was subjected to the force moulting technique recommended by Wilson et al. (NAR 40, 4216). The drinking water, given freely, and the basal diet had Na 26 and 270 mg/kg. Feed intake and bodyweight of

hens on the low-salt diet or force-moulted decreased significantly and egg production ceased during the moult. The reproductive organs of hens given the low-salt diet regressed to about 25% of the original size. When hens returned to the control feed, recovery was complete with significant increases in egg weight and egg specific gravity for hens on treatment 2. Egg production was greater for hens which got low salt and those force-moulted than for the control hens after the moult period.

Descriptors: egg production, hens, salt deprivation, forced resting

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Oliveira RM de; Bertechini AG; Oliveira AIG de (1997). **Egg quality of commercial laying hens submitted to four methods of moulting induction.** [Qualidade dos ovos de poedeiras comerciais submetidas a quatro metodos de inducao de muda.] *Ciencia e Agrotecnologia* 21(1): 103-108.

Universidade Federal de Lavras (UFLA), CP 37, 37200-000, Lavras, MG, Brazil.

NAL Call Number: S15 C53

A trial was carried out with 192 commercial laying hens (ISA Babcock B-300), 64 weeks of age and averaging 75% production, housed in pairs, in wire cages. The following treatments were applied: (1) 5 days with no ration; (2) 10 days with no ration; (3) 3 days with no ration followed by feeding with broken corn and sorghum grains for 9 days, and (4) feeding with a ration with a high level of zinc for 12 days. All treatments gave statistically similar results for egg specific gravity, egg weight, albumen height and Haugh Units. Shell thickness, shell weight and specific gravity increased significantly (by 0.29%, 5.35% and 7.37%, respectively) from 68 to 73 weeks of age. Shell thickness was greatest with treatment (3) and this treatment is recommended for obtaining the best egg quality in second cycle production.

Descriptors: age, hens, egg quality, egg weight, poultry, egg albumen, eggs, egg shell, diets, zinc, moulting, feeding, management, plane of nutrition

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Oliveira RM de; Hossain SM; Oliveira AIG de; Bertechini AG (1996). **Methods of inducing molting in commercial laying hens.** [Metodos de inducao de muda em poedeiras comerciais.] *Ciencia e Agrotecnologia* 20(3): 394-400.

NAL Call Number: S15 C53

To improve performance in the second production cycle of laying hens, a trial was carried out with six methods of induction of molting. A total of 288 commercial laying hens, 64 weeks old and averaging 75% of production, housed in pairs in wire cages, were used. The treatments were the following: five days without ration (T1); ten days without ration (T2); three days without ration followed by feeding with broken maize and sorghum grains for nine days (T3); ration without limestone or salt for twelve days (T4); ration with a high level of zinc for twelve days (T5); and ration with a high level of iodine for 12 days (T6). Maize and soyabeans were used as the basal diet. Treatments did not differ statistically ($P > 0.05$) with regard to egg production. T1 and T4 showed lower feed intake and best feed conversion per dozen eggs. T2, T4 and T6 showed higher average egg weight. T1 and T4 showed best performance in the second cycle of egg production.

Descriptors: egg production, egg weight, molting, induction, starvation, maize, grain, limestone, salt, zinc, iodine, feed intake, feed conversion efficiency, poultry

Parsons CM; Ridlen SF (1984). **Nutritional comparison of force molting methods.** *Poultry Adviser* 17(9): 57-60.

Poultry Cooperative Extension Service, USDA, Univ. Illinois, Urbana-Champaign, 1301 West Gregory Drive, Urbana, Ill. 61801, USA.

NAL Call Number: SF481 P622

A short review compares 3 types of diet for forced moulting of laying hens. Those are a low-protein molting diet based on maize, a pullet-developer moulting diet with protein 14 to 16%, and a low-sodium diet, all used in USA.

Descriptors: moult, diets, hens

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Pavlovski Z; Milovanovic M; Masic B (1992). **Periodic induced rest in layers. (Periodicno indukovanje odmora kod nosilja konsumnih jaja.)** *Peradarstvo* 27(7-9): 64-69.

NAL Call Number: SF481 P4

In a pilot trial Isabrown layers kept in individual cages 80 weeks of production were divided in 4 groups with 29 birds in each group. Group A was a control group (no induced rest), and in other experimental groups some rests were induced by low-sodium diet (group B after 40 weeks of production, group C after 28 and 56 weeks of production, group D after 20, 40 and 60 weeks of production). Average number of eggs per hen housed was the highest in group C (373 eggs), and the lowest in group D (352 eggs), but the difference was not significant. The results obtained in this pilot trial have suggested that periodic rest induced by low-sodium diet is not so efficient in improving performance of layers in a longer production period.

Descriptors: layer chickens, rest, eggs, laying performance, animal products, biological rhythms, birds, chickens, domestic animals, domesticated birds, galliformes, livestock, performance

Praharaj NK; Rao SVR; Raju MVLN; Chawak MM; Mishra SK; Mohapatra SC (1994). **Combined feeding of zinc, iodine and salt-free diet for inducing moult and its effect on subsequent performance of layer.** *Indian Journal of Poultry Science* 29(2): 142-145.

Project Directorate on Poultry, Rajendranagar, Hyderabad 500 030, India.

NAL Call Number: SF481 I5

300 White Leghorn hens, 67 weeks old, were studied. A standard layer diet devoid of salt but supplemented with iodine 3750 (SFI), zinc 7500 (SFZ) or iodine 2500 + zinc 5000 mg/kg (SFIZ) and a standard diet with salt and supplemented with iodine 3750 + zinc 7500 mg/kg (IZ) was used to induce moulting, and compared with a control diet that did not induce moulting. The results showed a significant decline in egg production in all groups during the 17 days of moulting, the effect being more pronounced in SFZ hens. Body weight loss during moulting and gain in weight during the subsequent laying cycle were also highest in SFZ hens, followed by the SFIZ, SFI and IZ groups. During the post-moult period, hen-housed egg production and feed conversion efficiency were significantly higher in all the moulted groups compared with the controls, but with no differences among the moulted groups. Egg weight was significantly

higher in the IZ group followed by the SFI group. Eggs produced by moulted groups were significantly superior to those from controls for albumen index and Haugh unit score. 12 ref.
Descriptors: zinc, iodine, supplements, moulting, induction, sodium chloride, body weight, egg production, egg quality, feed conversion efficiency
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Ross E; Herrick RB (1979). **Forced rest induced by molt or low-sodium diet on subsequent hen performance.** *Poultry Science* 58(4): 1101.
Dep. Animal Sciences, Univ. Hawaii, 1800 East-West Road, Honolulu, HI 96822, USA.
NAL Call Number: 47.8 AM33P
Descriptors: egg production, molting, sodium intake

Ross E; Herrick RB (1981). **Forced rest induced by molt or low-salt diet and subsequent hen performance.** *Poultry Science* 60(1): 63-67.
Dep. Animal Sciences, Univ. Hawaii, Honolulu, Hawaii 96822, USA
NAL Call Number: 47.8 AM33P
Four strains of laying hens (1534 birds), were force-moulted by one of 2 procedures when 66 weeks of age. In treatment 1 birds had the feed withheld for 10 days and day length reduced to 8 h, after which a low-protein diet was given. In treatment 2 birds were fed on a low-salt diet, containing 0.13% sodium, and subjected to the same lighting as those in treatment 1. Egg production of hens on treatment 2 decreased gradually to 13% after 38 days whereas those on treatment 1 were completely out of production in 7 days. After 5 weeks all birds were restored to the standard layer diet and 14 h light daily. Hen-day egg production of birds on treatments 1 and 2 was 63.1 and 55.2%, respectively, from 72 to 102 weeks of age, with feed intakes of 1.90 and 2.19 kg/12 eggs. Bodyweight gain, egg specific gravity and egg weight for birds on treatment 2 were also less than on treatment 1. The cause was attributed to a higher dietary Na content than the 0.044% intended.
Descriptors: egg production, moult, sodium, intake, hen feeding, low-sodium diet
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Salyi G (1985). **Decrease in egg production caused by insufficient sodium chloride (NaCl) supply in a commercial laying flock. [Hianyos konyhaso- (NaCl-) ellatas okozta tojastermeles- csokkenes nagyuzemi tojotyukallomanyokban.] Magyar Allatorvosok Lapja** 40(4): 221-224.
Tabornok u. 2., 1149 Budapest, Hungary.
NAL Call Number: 41.8 V644

A significant decrease in egg production, accompanied by cannibalism and molting occurred in a commercial flock of about 136 000 hens. Sodium in the feed varied between 0.053 and 0.08% and the lowest rate of egg production, varying between 15.8 and 30.6%, occurred 3-4 weeks after consuming this feed. Egg production increased again after supplementation of diets with NaCl. It is concluded that giving diets low in NaCl is not a safe and effective method of force-moulting in preparation for a second production cycle. 15 ref.
Descriptors: sodium chloride, deficiency, egg production, nutrient deficiencies
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Santoprete G; Fini MA (1984). **Changes in the zinc content of eggs of hens subjected to induced moult.** [Variazioni del contenuto di zinco nelle uova di galline sottoposte a muta forzata.] *Avicoltura* 53(3): 45-47.

Cattedra di Merceologia, Pisa Univ., Pisa, Italy.

NAL Call Number: 47.8 R523

In egg yolks of hens given diets with 1% zinc oxide to induce moult, Zn increased from 49.8 to 93.9 $\mu\text{g/g}$ after 17 days. Zn in albumen was unchanged. 18 ref.

Descriptors: zinc, eggs, moult

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Sarica M; Ozturk E; Karacay N (1996). **Effects of different forced molting methods on egg production and egg quality traits.** [Degisik zorlamali tuy dokum programlarinin yumurta verimi ve yumurta kalitesi uzerine etkileri.] *Turk Veterinerlik ve Hayvancilik Dergisi* 20(2): 143-150.

Ondokuz Mayıs Universitesi, Ziraat Fakultesi, Zootečni Bölümü, Samsun, Turkey.

NAL Call Number: SF1 D57

This study was conducted to compare fasting or feeding a high-zinc diet as procedures to induce cessation of laying. Ross Brown hens, aged 68 weeks, were used for the experiment. Daily light was supplied in the molting period. Three groups were fasted (no feed and water); 2 other groups received a diet with 10 000 or 15 000 p.p.m. zinc for 9 days. For the 5 groups, body weight loss 10 days after initiation of treatment was 13.72, 15.64, 14.16, 15.39 and 16.37% respectively, egg production during the resting period 7.19, 3.22, 2.61, 4.73 and 5.65, and egg production in the 2nd laying period 108.30, 109.21, 114.86, 108.63 and 113.06 (in 161 days). There were no significant differences in egg production among the treatments. Very low mortality was noted in all groups with no apparent differences. For the 5 groups, survival rate was 94.99, 96.69, 96.23, 98.23 and 96.38% respectively in the resting period, and 94.88, 96.87, 95.52, 96.92 and 92.77 in the 2nd laying period. For the 5 groups, egg weight averaged 68.83, 68.10, 68.25, 69.07 and 69.12 g respectively and shell thickness 335.27, 320.72, 337.67, 320.63 and 336.45 μm . Egg shell strength, shell thickness and yolk index were different ($P < 0.05$) among groups. It is suggested that any of the procedures can be used with commercial laying hens.

Descriptors: hens, fasting, zinc, supplements, molting, induction, egg production, egg weight, egg quality, egg shell, body weight, change, poultry

Setioko AR; Coligado EC (1987). **Effect of forced molting treatments on the productivity of itik [mullard] and Tsaiya ducks [Philippines].** *Philippine Journal of Veterinary and Animal Sciences* 13(4): 46-47.

NAL Call Number: SF1 P53

While molting has been widely employed on commercial duck farms as a production technique for many years in some countries, very little published information is available concerning production responses to specific methods of inducing the molt. This study was designed to investigate the effect of high level of dietary zinc and the system of feed and water deprivation as specific techniques of forced molting in layer ducks on their production

performance as well as the physiological behavior such as feather shedding, replacement and growth of new feathers. One hundred forty four layer ducks and 24 drakes were used in this study. Seventy two ducks and 12 drakes were the Tsaiya (a Taiwan egg type duck) and an equal number were the itik (local Mallard). Two levels of zinc oxide (15 g/kg and 30 g/kg diet) and feed and water deprivation methods were compared. Data from this study showed that forced molted ducks generally had higher total egg production as compared to the control. The level of 15 g/kg zinc oxide technique was found to be more beneficial method for forced molting in itik and Tsaiya ducks. The feed and water deprivation technique caused too serious bodily stress particularly in Tsaiya ducks, so it took a longer time before they recovered and returned to egg production.

Descriptors: ducks, productivity, molting, zinc, egg production, restricted feeding, Philippines, agriculture, animal feeding, animal production, animals, anseriformes, Asia, biological rhythms, birds, domestic animals, domesticated birds, elements, feeding, feeding systems, game, game birds, heavy metals, industrial pollutants, injurious factors, metals, nutrition, pollutants, poultry, production time, timing, vertebrates, zootechny

Shippee RL; Stake PE; Koehn U; Lambert JL; Simmons RW, III (1979). **High dietary zinc or magnesium as forced-resting agents for laying hens.** *Poultry Science* 58(4): 949-954.
Dep. Nutritional Sciences and Statistics, Univ. Connecticut, Storrs, Conn. 06268
NAL Call Number: 47.8 AM33P

Single-Comb White Leghorn hens aged 58 weeks in 5 groups of 18 were force-moulted, by deprivation of water for 48 h and of feed for 9 days then free intake of diet with 10% crude protein, or by being given in their laying diet for 14 days 1% zinc as acetate or oxide, or 2% magnesium as acetate or oxide. The Zn as acetate or oxide depressed feed intake and stopped egg laying within 6 days; then the hens resumed production in the next 24 weeks as they did after deprivation of feed and water. Mg was less effective; egg laying did not stop completely and the eggs had lower Haugh units and d and thinner shells. 11 ref.

Descriptors: feed intake, hens, egg production, animal feeding, toxicity, moulting, magnesium, zinc

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Sloan, DR; Harms, RH (1992). **Research note: Effect of removing salt from the diet of broiler breeder hens.** *Poultry Science* 71(4): 775-777.

University of Florida, Gainesville, FL

NAL Call Number: 47.8 AM33P

Two 28-day experiments were conducted utilizing 75-wk-old Arbor Acres broiler breeder hens to determine the effect of removing salt from the diet. Birds in Experiment 2 had been force-rested at 60 wk of age but were in production (65% hen-day) at experiment initiation. All hens received a corn-soybean meal diet either with or without added salt. Egg production was significantly reduced in both experiments by the end of the 4th wk for birds fed the diet with no added salt. However, egg production did not cease in hens receiving the diet with no added salt. Egg weights from hens receiving the diet with no added salt were significantly reduced by the end of Week 2 in Experiment 1 and Week 3 in Experiment 2. Specific gravity

was only intermittently affected by dietary salt removal. Birds receiving no added salt lost 541 and 580 g in Experiments 1 and 2, respectively. Birds receiving added salt diets gained 55 and 23 g in Experiments 1 and 2, respectively. Removing salt from the diet was not an acceptable method of force-resting broiler breeder hens.

Descriptors: broilers, hens, salt, egg production, egg weight, specific gravity, feed intake, forced rest

Stevenson MH; Jackson N (1984). **Comparison of dietary hydrated copper sulphate, dietary zinc oxide and a direct method for inducing a molt in laying hens.** *British Poultry Science* 25(4): 505-517.

NAL Call Number: 47.8 B77

The experiment lasted for seven 28-d periods. Laying hens of two breeds were allocated to 10 treatments. For the first 28-d period all birds were offered the control diet and then the following dietary treatments applied: a control group not molted, one group molted traditionally, 4 groups molted using CuSO₄- and 4 using ZnO-containing diets. After the molting treatments the hens were offered the control diet for the remainder of period 2 and for a further five 28-d periods. The treatments applied during period 2 significantly reduced food intake, body weight, egg number, total egg weight and efficiency of food conversion. On returning to the control diet, there were no significant differences in cumulative food intake (periods 3 to 7). Body weight had returned to the same value as the control group by the end of period 3. Dietary treatments significantly reduced the efficiency of food utilisation during periods 3 to 7 and 1 to 7 inclusive. For periods 1 to 7 inclusive the birds force-molted using CuSO₄ and ZnO gave on average greater egg numbers and total egg weights than those molted traditionally. The Haugh unit score was significantly improved after molting. Egg Zn concentrations were increased by the 14-d ZnO treatments. The use of a diet containing CuSO₄ (2 g added Cu/kg for 7 d) was as effective as one containing ZnO (20 g added Zn/kg for 14 d) and both were superior to a traditional force-molting technique.

Descriptors: hen feeding, molting, zinc oxides, copper sulfate, feed intake, egg production, egg shell thickness, egg albumen, haugh units

Verheyen G; Decuypere E (1991). **Egg quality parameters in a second and third laying year as a function of the moulting age, strain and moulting method.** *Archiv fur Geflugelkunde* 55(6): 275-282.

Laboratorium voor Fysiologie der Huisdieren, Kardinal Mercielaan 92, 3030 Herverlee, Belgium

NAL Call Number: 47.8 AR2

600 White Leghorn Hisex and 600 Warren SSL pullets in battery cages were subjected to forced moulting by means of starvation or a high-zinc diet at 54, 62, 70 or 78 wk of age. Age at moulting and strain had a highly significant effect on egg weight in the 2nd year of production, with hens treated at 54-62 wk and Warren hens showing the best performance. There was a significant age x strain interaction, but method of moulting did not affect egg weight. The egg shell quality in the 2nd yr improved after forced moulting for Hisex hens, irrespective of age, but that of Warren hens did not. The incidence of broken eggs in the 2nd

laying year was 2.64, 2.71, 3.02 and 3.15% in birds forced to moult at the 4 ages resp., and in the 3rd yr it was 3.19, 3.65 and 4.08% in groups 1, 2 and 3. Hisex birds produced a significantly greater percentage of broken eggs than Warren hens. Albumen quality was generally better in white than in brown eggs, and the Haugh unit score decreased with increasing age, in particular for Warren birds. Albumen quality appeared to be negatively correlated with egg weight in older birds subjected to forced moulting.

Descriptors: laying performance, moult, strain differences

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Verheyen G; Helsen J; Decuypere E (1990). **Accumulation of zinc in egg yolk, ovarian follicles and organs after forced resting by high dietary zinc.** *British Poultry Science* 31(1): 147-154.

Catholic University of Leuven, Laboratory for Physiology of Domestic Animals, Kard Mercierlaan, Belgium.

NAL Call Number: 47.8 B77

1. Eighteen Warren SSL hens of 71 weeks of age were forced-molted by ad libitum feeding of a high-zinc diet (10,000 ppm zinc for 2 days followed by 5,000 ppm zinc-supplement diet for 4 days). From the start of the treatment, eggs were collected and 3 hens were slaughtered on days 0, 2, 3, 4, 5 and 6 of the study. 2. Zinc analyses were carried out on the different components of the eggs and on liver, pancreas, kidney, different yolky follicles of the ovary and various segments of the oviduct. 3. Seven-, six- and threefold increases in zinc concentration were found in pancreas, liver and kidney, respectively. 4. The shell gland and isthmus, but not the magnum, also showed slight but significant increases in Zn content. 5. Zinc accumulation was also high and almost identical in ovarian follicles F1 to F4 but slightly less in F5 and F6 follicles. 6. In the egg, a significant increase in zinc concentration was only observed in the yolk.

Descriptors: Chickens--metabolism--ME, Egg Yolk--analysis--AN, Ovarian Follicle--metabolism--ME, Zinc--pharmacokinetics--PK, Kidney--analysis--AN, Kidney--metabolism--ME, Liver--analysis--AN, Liver--metabolism--ME, Ovarian Follicle--analysis--AN, Oviducts--analysis--AN, Oviducts--metabolism--ME, Pancreas--analysis--AN, Pancreas--metabolism--ME, Tissue Distribution, Zinc--analysis--AN

Whitehead CC; Sharp PJ (1976). **An assessment of the optimal range of dietary sodium for inducing a pause in laying.** *British Poultry Science* 17(6): 601-611.

ARC Poultry Research Centre, King's Buildings, West Mains Road, Edinburgh EH9 3JS, UK.

NAL Call Number: 47.8 B77

Laying hens were fed on a diet with Na 0.9 g/kg until 34 weeks of age, then groups were fed on diets with 0.2, 0.3, 0.4, 0.5, 0.6 or 0.9 g/kg for 16 weeks before that with Na 0.9 g/kg was reintroduced for all birds. Egg production and feed intake were depressed by the low-Na diets in proportion to the Na content. Birds receiving Na 0.3 to 0.6 g/kg diet lost weight initially but subsequently gained; birds receiving 0.2 g/kg diet lost weight continuously. In birds on

Na 0.2 g/kg diet, the reproductive organs completely regressed, whereas the organs resembled those of point-of-lay pullets in birds on Na 0.3 or 0.4 g/kg. When the control diet was reintroduced, birds which had low-Na diets resumed normal egg production and feed intake and regained bodyweight. The range of dietary Na for inducing a pause in egg laying is 0.3 to 0.4 g/kg.

Descriptors: egg production, nutrient requirements, hens, feed intake, moult, induction, sodium

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Williams JB; Etches RJ; Rzasz J (1985). **Induction of a pause in laying by corticosterone infusion or dietary alterations: effects on the reproductive system, food consumption and body weight.** *British Poultry Science* 26(1): 25-34.

Sta. Recherches Avicoles, Centre INRA de Tours-Nouzilly, 37380, France.

NAL Call Number: 47.8 B77

A pause in laying was induced in hens by infusing 30 micro g corticosterone/h, feeding diets deficient in calcium or sodium, or by food and water withdrawal. In hens infused with corticosterone, food consumption remained high and body weight was unchanged, although liver weight doubled. The other treatments were associated with a decline in food consumption and a loss in body weight, but liver weight was unchanged. Ovary weight was reduced most severely in hens given corticosterone, but the number of follicles weighing >12 mg was not altered by any of the treatments. A decrease in the number of large yolk-filled follicles was matched by an increase in the number of small ones. All treatments resulted in an increase in the number of atretic follicles, an elevation of plasma corticosterone concentration within the normal physiological range, and a decrease in plasma LH concentration.

Descriptors: molt, induction, corticosterone, corticoids, feed restriction, nutrition, sodium deficiency, calcium deficiency, water restriction

HORMONAL AND PHARMACEUTICAL INDUCED MOLTING

Attia YA; Burke WH; Yamani KA (1993). **Response of broiler breeder hens to forced molting by hormonal and dietary manipulations.** *Poultry Science* 73(2): 245-258.

NAL Call Number: 47.8 Am33P

Experiments were conducted to compare dietary and hormonal techniques for molting broiler breeder hens. In the first experiment, production dropped to 5% 3 wk after hens were restricted to an intake of one half of their calculated energy requirement (FR). Egg production levels of hens given a single i.m. injection of the Lupron Depot® formulation of leuprolide acetate (LA) in a dose intended to provide 10 microgram/kg BW per d for 30 d dropped to 9.5% whereas production dropped to 33% in hens receiving 5 microgram and was unchanged by 2.5 microgram. Postmolting fertility and hatchability of eggs from the FR and the 10-microgram LA groups were not different. In the second experiment, postinjection egg production, oviduct weight, and uterus weight were depressed, in a dose-related manner, when hens received 0, 10, or 22 microgram LA/kg per d. In a third experiment, egg production dropped to zero within 2 wk when hens were deprived of feed (FD) or deprived of feed and light (FD + LR), whereas it reached zero in 4 wk in hens fed only 30 g of wheat shorts per d (FR). Lupron Depot® at a dose intended to deliver 30 microgram/kg BW per d, reduced egg production to 9.5% by the 3rd wk. Twenty-eight weeks postmolting, egg production ranged from 84 to 98 eggs per hen in the molted groups and 56 eggs per hen in the unmolted controls. Fertility ranged from 82.1% in the FD + LR groups to 69.8% in the unmolted controls, whereas chick production averaged 36, 50, 59, 60, and 68 chicks per hen in the unmolted controls and in hens molted by LA, FR, FD, or FD + LR, respectively. Descriptors: hens, broilers, molting, feed intake, restricted feeding, fasting, light regime, molting hormones, laying performance, feed conversion, egg hatchability, weight, organs, egg shell, specific gravity, blood plasma, fatty acids, dosage ; Identifiers: leuprolide acetate

Burke WH; Attia YA (1994). **Molting single comb White Leghorns with the use of the Lupron Depot formulation of leuprolide acetate.** *Poultry Science* 73(8): 1226-1232.

NAL Call Number: 47.8 Am33P

Reproductive tract regression and cessation of egg production was induced in 80-wk-old Hy-line W36, strain hens by an i.m. injection of Lupron Depot at a dose calculated to release 60 microgram of leuprolide acetate (LA)/kg of BW for 30 d, by restriction of feed intake (FR) for 28 d, or by total feed deprivation (FD) for 7 d followed by feed restriction for 21 d. Egg production in LA and FD groups dropped to 24 and 19% in the first 7 d after initiation of the treatments and to 3.5 and 0% in the 2nd wk. Production of the FR group dropped to 38% during the 1st wk and to 1.7% in the 2nd wk. Production of both nutritionally deprived

groups remained near zero through the 5th wk, whereas it increased to 8.2% in the LA group at that time. Hens injected with LA reached 50% production at about 37 vs 45 d for both nutritionally deprived groups. Egg production of control groups remained unchanged during this time. Shell characteristics did not differ significantly among the molted groups throughout most of the 16 wk of the experiment. However shell weight and shell weight per unit surface area of eggs from LA-treated hens were significantly (P less than or equal to .05) lower than those of FR, but not FD, hens at several times. Mean values for shell characteristics of eggs from unmolted hens were significantly lower than those of molted hens. There were no differences in albumen quality between any of the groups at any time. Hens molted by FR and FD lost 23 and 26% of their initial BW, respectively, 4 wk after the initiation of the experiment. There was no loss of weight in LA-treated or control hens. Descriptors: hens, molting hormones, controlled release, LHRH, hormones, agonists, molting, restricted feeding, fasting, laying performance, ovaries, oviducts, weight, body weight, egg weight, egg albumen, egg quality, egg shell quality, leuprolide acetate

Dickerman RW; Bahr JM (1989). **Molt induced by gonadotropin-releasing hormone agonist as a model for studying endocrine mechanisms of molting in laying hens.** *Poultry Science* 68(10): 1402-1408.

University of Illinois, Urbana, IL

NAL Call Number: 47.8 AM33P

Descriptors: hens, gonadotropin releasing hormone, molt, molting, laying performance, weight losses, thyroxine, triiodothyronine, progesterone

Dvorak M; Sevcik B; Hyhlik J (1971). **Effect of ICI 33828 on delay of egg production in pullets and on moulting in hens. [Overeni ucinku latky ICI 33828 na oddaleni snasky u kuric a prepereni nosnic.]** *Veterinaria SPOFA* 13(5/6): 285-296.

NAL Call Number: SF1 B5

Administration of 30 mg ICI 33828/kg food to 100 White Plymouth Rock pullets aged 130 days for 42 days inhibited egg production in 86.1%. After the withdrawal of treatment, egg production resumed immediately and in the 30 days following was higher than in untreated controls. The same dose was given to 264 White Leghorn pullets for 42 days. Over 134 days from the onset of treatment, egg production/pullet averaged 12.5, egg weight 47.5 g, hatchability of eggs set 87.1%, and hatchability of fertile eggs 90.0% v 15.8, 44.4 g, 87.4% and 90.7% resp. in 265 untreated controls. Administration of 100 mg ICI 33828/kg food to 950 White Leghorn hens for 4 days at the end of the 9th mth of lay induced moulting in 80.7% within 20 days.

Descriptors: metallibure, performance, egg production, egg weight, egg hatchability, egg fertility, moult, induction

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Edens FW; Thaxton JP (1988). **Method of Inducing Birds to Molt Us Patent-4761398. August 2 1988.** *Official Gazette of the US Patent and Trademark Office Patents* 1093 (1): 271.

Patent Number: US 4761398 Patent Classification: 514015000

NAL Call Number: T223 A21
Descriptors: USCL-514-15, Hens, LHRH

Herremans M; Decuyper E; Chiasson RB (1988). **Role of ovarian steroids in the control of moult induction in laying fowls.** *British Poultry Science* 29(1): 125-136.

NAL Call Number: 47.8 B77

Descriptors: hens, molt, thyroxine, triiodothyronine, progesterone, estradiol, hormonal control, oviposition

Hoyle CM; Thaxton JP; Morgan GW; Schally AV (1988). **Administration of microencapsulated 6-d tryptophan LHRH induces SCWL hens to molt.** *Poultry Science* 67(SUPPL.1): 19.

NAL Call Number: 47.8 AM33P

Descriptors: hormone, egg production, reproductive tract regression

Ishigaki R; Ohori Y; Ebisawa S; Kinbara K; Yamada Y; Nakajo S (1971). **Forced molting by Metallibure (I.C.I. 33, 828), a nonsteroid anti-gonadotropic compound. 1.** [Poultry] *Japanese Poultry Science* 8(2): 77-81.

NAL Call Number: 47.8 N57

Prochazka F; Hyhlik J; Sevcik B; Dvorak M (1971). **Effect of the preparation VUFB 7319 on inhibition of egg production at the end of the laying period and on forced moulting. [Sledovani ucinku latky VUFB 7319 na preruseni snasky u nosnic na konci snaskoveho obdobi a na nucene prepereni.]** *Veterinaria SPOFA* 13(5/6): 329-345.

Okresni veterinarni zarizeni, Pisek, Czechoslovakia.

NAL Call Number: SF1 B5

100 mg VUFB/kg food was given to 1260 White Leghorns for 5-6 days at the end of the laying period (28-33% production). Egg production ceased within 11 days of the beginning of treatment; moulting started on day 5 and lasted for 20-35 days. 94% of hens moulted. A 50% resumption of egg production was recorded within 10 wk.

Descriptors: egg production, moult, progestogens, White Leghorn

Ruszler PL; Beane WL; Wolford JH (1984). **Corticosterone and feed withdrawal as a forced rest technique in laying hens.** *Poultry Science* 63(Suppl. 1): 35.

Department of Poultry Science, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

NAL Call Number: 47.8 AM33P

Sander H; Speck J (1976). **Regulation of stress-free laying pauses using chlormadinone acetate. [Steuerung stressloser Legepausen mittels Chlormadinonacetat.]** *Deutsche Tierarztliche Wochenschrift* 83(10): 451-455.

Tierarztliches Institut der Universitat Gottingen, 34 Gottingen, German Federal Republic.

NAL Call Number: 41.8 D482

240 Arbor Acre hens, which had been in lay for 60 wk, were divided into 7 groups and

installed in 3-bird cages. Three groups were given CAP for 10 days (10, 13 or 16 mg/kg food) and 3 groups for 20 days (7, 10 or 13 mg); a 7th group served as untreated controls. For the 6 treated groups resp., the laying paused lasted 15.1, 20.7, 23.1, 13.8, 25.8 and 26.0 days, laying rate in the 7th-15th wk after beginning of treatment was 55.2, 62.4, 58.5, 54.4, 59.1 and 62.9%, and egg weight averaged 58.9, 58.2, 57.9, 60.8, 57.7 and 59.2 g. In the control group, laying rate was 48.9% and egg weight averaged 59.5 g. Egg shell strength improved after CAP treatment.

Descriptors: moult, induction, laying performance, progestogens, CAP, stress, chlormadinone, egg production

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Schneider K-H; Gruhn K (1974). **The effect of forced moult induced by staggered administration of methionine on egg production during the second year of laying.** [Der Einfluss der Zwangsmauser unter Einsatz gestaffelter Methioningaben auf die Eiproduktion im zweiten Legejahr.] *Tierzucht* 28(2): 83-86.

Sektion Tierproduktion und Veterinarmedizin, Karl-Marx-Universitat, Leipzig, German Democratic Republic.

NAL Call Number: 49 T443

Moulting was induced in half of 360 White Leghorn hens (A) and half of the hens were allowed to moult naturally (B). Mortality during the 2nd year of laying averaged 7.2% in group A v 14.1% in group B, body weight at the beginning and end of the 2nd year averaged 1798 and 1915 g resp. v 1894 and 1903 g, egg production/hen 195.2 v 186.2, and egg mass 11.8 v 11.2 kg. There were no significant differences between the groups in food conversion or egg shell thickness.

Descriptors: food conversion, egg shell thickness, methionine, moult, induction, egg production, mortality, body weight, egg mass, hens, moulting.

Sekimoto K; Imai K; Suzuki M; Takikawa H; Hoshino N; Totsuka K (1987). **Thyroxine-induced molting and gonadal function of laying hens.** *Poultry Science* 66(4): 752-756.

NAL Call Number: 47.8 AM33P

Descriptors: hens, thyroxine, molting, hormonal control, triiodothyronine, luteinizing hormone, progesterone, body weight, egg production

Sirotkin AV; Golubev AK (1983). **Circadian changes in sensitivity of the chicken to exogenous hormones influencing molt and reproduction.** *Journal of Evolutionary Biochemistry and Physiology* 19(6): 422-426. [Translated from: Zhurnal evoliutsionnoi biokhimii i fiziologii, p. 565-570. (QH345.Z5).]

NAL Call Number: QP1.J725

Stake PE; Frederickson TN; Okulicz W; Shippee RL; Fournier DJ (1979). **Tamoxifen induced forced-rest/molt in laying hens.** *Poultry Science* 58(4): 1111.

Dep. Nutritional Sciences, Univ. Connecticut, Storrs, CT 06268, USA

NAL Call Number: 47.8 AM33P.

Descriptors: egg production, egg quality, moulting, hens, suppression

Szelenyi Z; Peczely P (1988). **Thyroxin induced moult in domestic hen.** *Acta Physiologica Hungarica* 72 (2) p143-149.

Laboratory of Geese Biochemistry, University of Agriculture, Godollo Hungary.

NAL Call Number: QP1 A17

Two identical experiments were carried out in domestic hens treated with a lower (0.2 mg/animal) or a higher (0.4 mg/animal) dose of thyroxin (T4), for 21 consecutive days. The low dose diminished egg production, but did not result in moulting while the higher dose stopped egg laying on the 16th day and caused the loss of contour feathers from the 14th day on. The new plumage was completely developed in this group on about the 42th day. The plasma progesterone concentration showed an increase in both thyroxin treated groups, but it was only continuous and significant in the fowls treated with 0.4 mg T4. In this group the peak value of progesterone was synchronous with the most intensive feather loss. In the other group the tendency for increased levels of progesterone was of shorter duration and not significant. Plasma oestrone levels were depressed by the treatment in both groups and increased significantly only in the moulted fowls after administration of T4 was stopped. This increase may be associated with feather growth and regeneration of the oviduct. Plasma 17-beta oestradiol and testosterone concentrations did not change in the T4 treated groups. Plasma corticosterone concentration increased continuously only in the moulting animals. The results suggest that on one hand thyroxin has a role in the endocrine regulation of moulting and, on the other, that a thyroxin-progesterone synergism is of significance in the process.

Descriptors: Chickens--physiology--PH, Feathers--physiology--PH, Thyroxine --pharmacology--PD , Corticosterone--blood--BL, Estradiol--blood--BL, Estrone--blood--BL, Feathers--drug effects--DE, Oviposition--drug effects--DE, Reference Values , Testosterone--blood--BL

Szelenyi Z; Peczely P; Vadocz E (1988). **Hormonal changes during forced moult induced by progesterone in domestic hen.** *Acta Physiologica Hungarica* 71(1): 69-75.

Institute of Physiology, University of Veterinary Science, Budapest, Hungary.

NAL Call Number: QP1 A17

Forced moulting has been induced in domestic hens by progesterone treatment (5 mg/day) for 25 days. Moult happened between the 11th and 19th day after the first treatment. Endocrine changes were followed during the moult by blood sampling in one week intervals. At the time of the last sampling, new egg laying cycle was initiated in all birds. Plasma progesterone concentration increased significantly in response to the treatment then tended to decrease. Oestrone and testosterone levels were the lowest during the period when feather loss was most intensive and increased in the course of feathering. This increase was significant in the case of oestrone. The level of 17-beta-oestradiol did not vary during moult induced by progesterone treatment. Plasma concentration of thyroxine significantly increased during feather loss, showing a maximum in the second and/or third week after the beginning of the treatment, while it decreased when feather growth had begun. Plasma triiodothyronine as well as corticosterone levels were the highest during the latest phase of moult, at the time of feather outgrowing. It has been supposed that moulting would be initiated in response to the

synergistic effect on feather follicles of progesterone and thyroxine, which was stimulated by the progesterone treatment. The atrophic stage of the ovary suggested that progesterone was probably of adrenal origin. It was assumed that triiodothyronine and oestrone were responsible for controlling feather outgrowth.

Descriptors: Chickens--blood--BL, Corticosterone--blood--BL, Progesterone--pharmacology--PD, Sex Hormones--blood--BL, Thyroid Hormones--blood--BL, Chickens--growth and development--GD, Feathers--growth and development--GD

Tilbrook AJ; Johnson RJ; Eason PJ; Clarke IJ (1990). **Induced pause in egg production using a synthetic hypothalamic peptide.** *Proceedings of the Australian Poultry Science Symposium* p.105.

Animal Research Institute, Department of Agriculture and Rural Affairs, Werribee, Vic. 3030, Australia.

Moulting induced by nutrient restriction is accompanied by a decrease in circulating LH and reduced sensitivity of the pituitary gonadotrophs to GnRH. To study if treatment with a GnRH agonist would induce a pause in egg production, laying fowls were (1) injected subcutaneously with saline for 7 days (controls), (2) nutrient-restricted (by whole oat feeding), (3) injected with 100 micro g/kg of a GnRH agonist for 7 days, or (4) implanted with slow-release pellets containing 120 micro g of the agonist. Egg production and LH concentration were lower in the 2 GnRH agonist treatments than in the controls, but those for the nutrient-restricted group were lower than for the GnRH agonist-treated groups.

Descriptors: gonadotropins, GnRH, agonists, effects, moult, induction, LH, blood
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Tomita Y; Hayashi K; Honbo T (1977). **Effects of citric acid on molting, egg production, activities of enzymes in liver and mineral levels in serum of natural molting hens.**

Bulletin of the Faculty of Agriculture Kagoshima University 27: 165-170.

NAL Call Number: 107.6 K114B

Verheyen G; Decuypere E; Chiasson RB; Vervloesem J; Kuhn ER; Michels H (1987). **Effect of exogenous LH on plasma concentrations of progesterone and oestradiol in relation to the cessation of egg laying induced by different moulting methods.** *Journal of Reproduction and Fertility* 81(1): 13-21.

NAL Call Number: 442.8 J8222

Artificially induced cessation of egg laying caused regression of the reproductive tract in hens, as well as changes in circulating concentrations of sex steroids. Hens were bled at several stages during and after artificial moult induced by fasting or overfeeding a diet low in calcium or high in zinc. Hens received a single injection of 200 i.u. of horse LH at Day 0, 7, 21, 35 and 77 (Exp. 1) or Day 0, 8, 23, 35 and 71 (Exp. 2) after start of the treatment to induce moult. Blood samples were taken before and 20, 40 and 60 min (Exp. 1) or 15, 30 and 45 min (Exp. 2) after LH injection. Hens which were fasted or given the diet high in zinc had low plasma progesterone concentrations and the response to LH was reduced or delayed. In hens fed low calcium the reduction in plasma progesterone was less pronounced and the responsiveness to LH was more or less maintained. Conversely, there was no response of oestradiol to LH in laying hens. However, oestradiol concentrations increased in moulting

hens after LH injection, due to the high oestradiol secretion from the small white follicles, since all yolky follicles were atretic.

Descriptors: hens, egg formation, laying performance, molting hormones, progesterone, estradiol, luteinizing hormone

Verheyen G; Decuypere E; Kuhn ER; Herremans M (1986). **Dissociation of the effect of thyroxine and triiodothyronine in relation to the halt, egg laying and moult in hens.** *Archiv für Experimentelle Veterinarmedizin* 40(2): 250-259.

Laboratory of Comparative Endocrinology, Zoological Institute, Naamsestraat 61, 3000 Leuven, Belgium.

NAL Call Number: 41.8 EX7

Injection of 0.7 mg thyroxine (T4) or triiodothyronine (T3) during 3 consecutive days was studied in Warren SSL hens at 82 wk of age. In both treatment groups, half the hens were fed a commercial layer diet ad lib., and half were force-moulted by removing food for 8 days followed by food restriction (relative to ad lib. intake) for 20 days. Following T4 injections in ad lib.-fed hens, egg production remained relatively constant, but the effect on feather loss was rapid and pronounced. The T3 injections, however, decreased egg production in ad lib.-fed hens, but had only a small effect on moult.

Descriptors: egg production, thyroid hormones, moult, hens

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Zhvikas EB (1976). **Effect of different methods of forced moulting on reproductive characters of laying hens.** [Vliyanie razlichnykh metodov prinuditel'noi lin'ki na vosproizvoditel'nye kachestva yaichnykh kur.] *Ptitsevodstvu* 4: 110-118, 142-143.

Sbornik Rabot. Pribaltiiskaya Zonal'naya Opytnaya Stantsiya po

NAL Call Number: Z5074 P8R4

Nine groups each of 75 Leghorn layers were treated as follows at the end of the 1st laying season: (1) controls, maintained under 14 h light daily and with access to food and water; (2) light stress (light period increased to 24 h daily for 10 days, shortened abruptly to 8 h daily for 1 mth, and then lengthened to 14 h daily) but with access to food and water; (3) light stress and with access to water but starved for 6 days; (4), (5), and (6) as in (3) but starved for 8, 10 or 12 days resp.; (7) light stress, with access to food and water, and fed 0.7 g thyroid extract daily; (8) as in (7) but injected with 50 mg progesterone; (9) darkness, and withdrawal of water and food for 3 and 4 days resp. For the 9 treatments resp., egg production to the onset of forced moulting at 68 wk of age averaged 247, 247, 244, 238, 246, 238, 250, 250 and 246 v 216, 191, 222, 247, 230, 228, 213, 192 and 226 in the following 52 wk, group 4 producing significantly more and group 2 significantly less than the controls. Production to 43 wk after the onset of forced moulting was significantly better in groups 3, 4, 5, 6 and 9 (201, 230, 217, 216 and 212) and worse in group 2 (156) than in controls (178). Egg fertility 3 and 11 mth after forced moulting was generally higher than in birds aged 15-16 mth, but hatchability of eggs set was lower (69.4-87.1 and 64.9-73.8 v 88.8-95.1%). Corresponding values for hatchability in the control group were 87.7 and 80.5% v 92.9.

Descriptors: moult, induction, laying performance

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SELECTED WEBSITES

Research proposed and Funded by PEPA for 2001/2002: Use of an aromatase inhibitor to stimulate molt in laying hens. California Poultry Letter May /June 2001, Cooperative Extension - University of California at Davis
<http://animalscience.ucdavis.edu/Avian/cplmayjune2001.pdf>

HISTOLOGICAL, METABOLIC, AND PHYSIOLOGICAL CHANGES

Akayama T; Terashima T; Okamoto T; Ogura K (1989). **Effects of "Tori Power", an anti-stress feed supplement for laying hens, following forced molting.** *JA Zenno Shiryo Chikusan Chuo Kenkyujo Shiken Kenkyu Hokoku* 16(1987): 165-170.

National Federation of Agricultural Co-operative Associations, Central Res. Inst. for Feed and Livestock

Descriptors: laying hen, chicken raising, formula feed, feed additive, feeding(supply), stress (physiology), resistance (endure), egg-laying, economy (efficiency), body weight, ovary (animal organ), chicken egg

Al-Batshan HA; Scheideler SE; Black BL; Garlich JD; Anderson KE (1994). **Duodenal calcium uptake, femur ash, and eggshell quality decline with age and increase following molt.** *Poultry Science* 73(10): 1590-1596.

King Saud University, Riyadh, Saudi Arabia.

NAL Call Number: 47.8 Am33P

An experiment was conducted to test the hypothesis that the decline in eggshell quality over time during egg production, and its improvement after molting, paralleled the rate of calcium uptake by the duodenum of the laying hen. In vitro duodenal calcium uptake rate and femur ash (percentage of femur weight) were determined at 37, 45, 51, 58, 68, and 72 wk of age. Percentage shell and shell thickness (millimeters) were determined at 22, 29, 36, 44, 50, 57, and 71 wk of age. Molt was induced at 63 wk of age. Three commercial strains DeKalb XL-Link, ISA/Babcock B-300V, and Hy-Line W-36 were compared. There were no differences in duodenal calcium uptake rate among strains. There was a significant decline ($P < .01$) in duodenal calcium uptake from 408 pmol/mg tissue per min at 37 wk of age to 329 pmol/mg per min at 58 wk of age. Femur ash decreased ($P < .01$) from 50.8% at 37 wk of age to 47.6% at 58 wk of age. Percentage shell and shell thickness declined ($P < .01$) from 9.79% and .403 mm at 22 wk of age to 8.88% and .373 mm at 57 wk of age, respectively. After the induced molt, duodenal calcium uptake increased ($P < .01$) to 402 pmol/mg tissue per min, and percentage shell and shell thickness increased ($P < .01$) to 10.23% and .389 mm, respectively. Duodenal calcium uptake increased immediately postmolt, whereas femur ash did not increase until 72 wk of age ($P < .01$).

Descriptors: hens, calcium, mineral uptake, duodenum, femur, bone ash, egg shell thickness, age differences, molting, strain differences

Balthazart J; Verheyen G; Schumacher M; Decuypere E (1988). **Changes in progesterone metabolism in the chicken hypothalamus during induced egg laying stop and molting.** *General and Comparative Endocrinology* 72(2): 282-295.

Laboratory of General and Comparative Biochemistry, Liege, Belgium.

NAL Call Number: 444.8 G28

In the present study, we have established and validated a radioenzyme assay which permits us to quantify progesterone metabolism in the chicken brain. Progesterone metabolism was then studied in five brain areas obtained by microdissection from the telencephalon (part of the lobus paraolfactorius immediately rostral to the preoptic area), the preoptic area, and the hypothalamus. Three metabolites of progesterone were produced in large amounts in these

brain regions and were quantified in this study: 5 beta-pregnane-3,20-dione (5 beta-DHP) as well as its metabolite 3 alpha-hydroxy-5 beta-pregnane-20-one (5 beta,3 alpha-ol) and 5 alpha-pregnane-3,20-dione (5 alpha-DHP). The unmetabolized progesterone was also recovered and quantified. The 5 beta-reduction of progesterone (production of 5 beta-DHP and 5 beta,3 alpha-ol) was very active but its 5 alpha-reduction (production of 5 alpha-DHP) was almost absent in the lobus paraolfactorius. An opposite pattern of metabolism was found in the preoptic area and the hypothalamus (higher 5 alpha- but lower 5 beta-reductase activity). The changes in progesterone metabolism in these brain areas were then studied in groups of hens submitted to induced egg laying stop and molting. A significant decrease in progesterone 5 alpha-reduction was found in the median hypothalamus of hens during the period of molt. Simultaneously, the experimental procedures induced significant decreases in the production of 5 beta-DHP by the lobus paraolfactorius, anterior, and medial hypothalamus but induced a significant increase in the production of this metabolite in the preoptic area. These changes are likely to be involved in the control of reproductive functions including sexual behavior and secretion of luteinizing hormone-releasing hormone, and a number of possible causal mechanisms are presented. These should now be tested experimentally especially in view of the very limited information which is now available on the biological effects of the metabolites of progesterone.

Descriptors: Brain--metabolism--ME; Chickens--physiology--PH; Hypothalamus --metabolism--ME; Oviposition; Progesterone--metabolism--ME ; 3-Hydroxysteroid Dehydrogenases--metabolism--ME; Kinetics; NADP--metabolism --ME; Oxidoreductases--metabolism--ME; Pregnanediones--metabolism--ME; Pregnanolone--metabolism--ME; Progesterone Reductase--metabolism--ME; Tissue Distribution

Barron LG; Walzem RL; Hansen RJ (1999). **Plasma lipoprotein changes in hens (*Gallus domesticus*) during an induced molt.** *Comparative biochemistry and physiology. Part B, Biochemistry & Molecular Biology* 123B(1): 9-16.

University of California, Davis, California

NAL Call Number: QP501.C6

Blood plasma lipoproteins were studied during food and light deprivation or prolactin injection-induced involution of ovarian follicles (molt) of laying hens. Egg laying stopped 3 days after initiation of either treatment. Food and light-deprived hens lost 29% of initial body weight during the 10-day experiment ($P < 0.05$), whereas prolactin-treated hens lost 9% of body weight. Yolk-directed very low density lipoprotein (VLDL_y) concentration in plasma decreased in both groups, but declined more rapidly in food and light-deprived hens. Very low density lipoprotein triacylglycerol decreased 40% in food and light-deprived hens by day 2 compared with a 13% decrease in the prolactin-treated hens. By day 5, a lipoprotein particle 21-22 nm in diameter appeared in the $d = 1.019-1.046$ g/ml density fraction of plasma in both groups. A similar lipoprotein particle, termed HDL_y, developed in overfed hens with involuting ovarian follicles. In conclusion, hens undergoing ovarian regression due to food and light deprivation, prolactin treatment or overfeeding display marked decreases in plasma yolk-directed very low density lipoproteins and the appearance of HDL_y. Other lipoprotein

populations varied depending on whether the hens continued to feed or not.
Descriptors: hens, molting, blood lipids, lipoproteins

Barron L; Walzem R L; Hansen R J (1992). **Appearance of novel lipoprotein in plasma of force-molted Single Comb White Leghorn hens.** *FASEB (FED AM SOC EXP BIOL) Journal* 6(4): A1390.
Dep. Physiol. Sci., Sch. Vet. Med., Univ. California, Davis, Calif. 95616.
NAL Call Number: 442.9 F31P

Berry WD; Brake J (1991). **Research note: induced molt increases eggshell quality and calbindin-D28k content of eggshell gland and duodenum of aging hens.** *Poultry Science* 70(3): 655-657.
North Carolina State University, Raleigh, NC
NAL Call Number: 47.8 AM33P
Aged laying hens, which were induced to molt by fasting to a 30% loss of their original body weight or by administration of a diet containing 2% zinc as zinc oxide, experienced reproductive involution and cessation of egg production. Both of the molting treatments resulted in improvement of eggshell density by time of oviposition of the 10th egg after the return to egg production postmolt. Both molting treatments significantly increased the amount of calbindin in the shell gland and duodenum of molted hens as compared with control hens at the 10th egg after return to egg production postmolt.
Descriptors: hens, aging, egg shell quality, molt, calbindin, shell gland, zinc, fasting, duodenum, weight losses

Berry WD; Gildersleeve RP; Brake J (1984). **Hens induced to molt by fasting or high dietary zinc exhibit hematological and splenic changes.** *Poultry Science* 63(Suppl.1): 64.
Dep. Poultry Sci., N.C. State Univ., Raleigh, North Carolina
NAL Call Number: 47.8 AM33P
Descriptors: erythrocytes, hematocrit, hemoglobin

Brake JT (1978). **The physiology of forced molting (hen).** *Dissertation Abstracts International*, B 39(2): 575.
NAL Call Number: Z5055.U49D53
Descriptors: feathers; haematology; blood chemistry; moulting

Brake J; Baker M; Morgan GW; Thaxton P (1982). **Physiological changes in caged layers during a forced molt. 4. Leucocytes and packed cell volume.** *Poultry Science* 61(4): 790-795.
NAL Call Number: 47.8 AM33P
Packed cell volume and circulating leucocyte numbers in force-molted, Single Comb White Leghorn (SCWL) hens were examined. Two groups of SCWL hens, reared under commercial conditions, were subjected to force molting (FM) at 70 (Trial 2) and 72 weeks of age (Trial 1). The force molting procedure consisted of a reduced photoperiod (6 hr), feed removal for 12 days (Trials 1 and 2), and water withdrawal for 1 day (Trial 1 only). Cessation of egg

production was achieved in 6 days. Control (CON) hens were maintained in each trial with no change in daylength, and feed and water were available ad libitum. The FM hens exhibited a significant increase in packed cell volume (PCV) from the time of feed removal until immediately prior to resumption of egg production. This effect was not associated with water deprivation. The FM hens exhibited numerically increased numbers of total leucocytes (TWBC) and monocytes throughout the nonlaying period. However, the increase was significant on Day 14 of both trials for TWBC and on Days 21 and 35 (Trial 1) and Days 14 and 48 (Trial 2) for monocytes. A significant eosinophilia was observed on Days 7 and 14 of both trials. Changes associated with lymphocytes, heterophils, and basophils were inconsistent. Lymphocytes were increased significantly in the FM hens of Trial 2 from Day 21 to Day 48, but no significant difference occurred in Trial 1. A heterophilia was exhibited by the FM hens of Trial 1 on Days 7 and 14, but not in Trial 2. Conversely, a significant basophilia was observed on Days 7 and 14 in Trial 2, but not in Trial 1. These data suggested that an increased PCV, eosinophilia, and possibly increased TWBC and monocyte numbers were associated with a forced molt in caged SCWL hens.

Descriptors: Chickens--physiology--PH; Hematocrit; Housing, Animal; Leukocyte Count--veterinary--VE ; Chickens--blood--BL; Eosinophils--cytology--CY; Lymphocytes--cytology--CY; Monocytes--cytology--CY; Oviposition

Brake J; Berry WD; Thaxton P (1985). **Cellular changes in the spleen during an induced molt.** *Poultry Science* 64 (5): 1031-1034.

NAL Call Number: 47.8 AM33P

Agranulocytes proliferated in spleens of molted hens and both leucocytic and erythrocytic cells exhibited decreased numbers of pyknotic nuclei. These changes were confined to the period when the reproductive tract regressed. It was concluded that there is a relationship between the physiological status during an induced molt and the cellular population of the spleen.

Descriptors: Chickens--physiology--PH; Spleen--cytology--CY ; Chickens--anatomy and histology--AH; Fasting; Lymphocytes--cytology--CY

Brake J; Morgan GW; Thaxton P (1981). **Recrudescence of the thymus and repopulation of lymphocytes during an artificially induced molt in the domestic chicken: proposed model system.** *Developmental and Comparative Immunology* 5(1): 105-12.

NAL Call Number: QR180 D4

Descriptors: *Feathers--physiology--PH; *Lymphocytes--physiology--PH; *Models, Biological; *Thymus Gland--physiology--PH ; Chickens; Lymphocytes--immunology--IM; Thymus Gland--immunology--IM; Time Factors

Brake J; Thaxton P (1979). **Physiological changes in caged layers during a forced molt. 1. Body temperature and selected blood constituents.** *Poultry Science* 58(3): 699-706.

NAL Call Number: 47.8 AM33P

Brake J; Thaxton P (1979). **Physiological changes in caged layers during a forced molt. 2. Gross changes in organs.** *Poultry Science* 58(3): 707-716.

NAL Call Number: 47.8 AM33P

The effects of forced molting on body weight and the absolute and relative weights of the liver, ovary, oviduct, right adrenal, and spleen were studied. White Leghorn hens which were reared and maintained under commercial conditions were force molted by reducing daylength as well as by withdrawing feed and water. This procedure induced a pause in egg production within one week of the initiation of feed removal. Four trials were conducted. In Trial 1 the hens were sampled at weekly intervals for 56 days beginning at the time feed was removed. In Trials 2, 3, and 4 the hens were sampled either daily or on alternate days for up to 22 days beginning at the time of feed removal. The absolute and relative weights of the liver, ovary, and oviduct were decreased significantly. Body weight decreased consistently. No consistent trend over the four trials was found in the absolute or relative weights of the right adrenal or the spleen.

Descriptors: Chickens--physiology--PH; Feathers ; Adrenal Glands--anatomy and histology--AH; Animal Feed; Body Weight; Chickens--anatomy and histology--AH; Light; Liver--anatomy and histology --AH; Organ Weight; Ovary--anatomy and histology--AH; Oviducts--anatomy and histology--AH; Spleen--anatomy and histology--AH

Brake J; Thaxton P (1976). **Changes in blood metabolites and body temperature during a forced molt.** *Poultry Science* 55(4): Abstract 1588.

NAL Call Number: 47.8 AM33P

Descriptors: chicken, protein, calcium, inorganic phosphate, glucose

Brake J; Thaxton P; Benton EH (1979). **Physiological changes in caged layers during a forced molt. 3. Plasma thyroxine, plasma triiodothyronine, adrenal cholesterol, and total adrenal steroids.** *Poultry Science* 58(5): 1345-1350.

NAL Call Number: 47.8 AM33P

The effects of forced molting on plasma levels of thyroxine (T4), triiodothyronine (T3), and adrenal cholesterol and total adrenal steroid content were studied. Commercially available strains of Single Comb White Leghorn (SCWL) hens, reared and maintained under commercial conditions, were used in the three trials. The hens were moved to environmentally modified facilities prior to the forced molt which was accomplished by reducing daylength and by withdrawing feed and water. Egg production ceased within one week of initiation of this procedure. The hens were sampled either daily or on alternate days for up to 22 days beginning at the time of feed removal. Plasma T4 initially decreased upon removal of feed, but increased above control levels by the sixth day of feed withdrawal. Plasma T3 levels remained relatively constant throughout the feed withdrawal period. Resumption of feeding with a fortified ground corn ration resulted in a decrease in T4 and concomitant increase in T3. Changes in adrenal cholesterol and total adrenal steroids were not consistent. However, there was a trend toward increased total adrenal steroids during feed withdrawal, and an increase in adrenal cholesterol upon the resumption of feeding.

Descriptors: Adrenal Cortex Hormones--metabolism--ME; Adrenal Glands--metabolism--ME; Chickens--physiology--PH; Cholesterol--metabolism--ME;

Thyroxine--blood --BL; Triiodothyronine--blood--BL ; Animal Feed;
Chickens--metabolism--ME; Housing, Animal

Brake J; Thaxton P; Pardue SL; Morgan GW (1977). **Changes in specific organs of laying hens during a forced molt.** *Poultry Science* 56(5): 1697-1698.

NAL Call Number: 47.8 AM33P

Descriptors: liver, ovaries, oviducts, adrenal glands, spleen, light, moulting

Cheshmedzhieva S; Dimov V (1994). **Metabolism of free fatty acids associated with albumin and lipoproteins in plasma of laying hens, subjected to forced molting.** [V"rkhu metabolizma na svobodnite mastni kiselini, sv"rzani s albumina I lipoproteinite v plazmata na kokoshki nosachki podlozheni na prinuditelno lineene]. *Zhivotnov"dni Nauki [Animal Science]* 31(5-6): 161-164.

Institut po Zhivotnov"dstvo, Kostinbrod Bulgaria and Selskostopanska Akademiya, Sofia Bulgaria

NAL Call Number: 49 Z65

Descriptors: layer chickens, forced moulting, free fatty acids, lipoproteins, triacylglycerol lipase, blood plasma, statistical analysis , acids, biological development, birds, blood, chickens, domestic animals, domesticated birds, enzymes, esterases, fatty acids, galliformes, hydrolases, livestock, moulting, organic acids, poultry, proteins

Cheshmedzhieva S; Dimov V (1989). **Cholesterol metabolism during induced moulting in laying hens.** *Zhivotnov"dni Nauki* 26(8): 57-62.

Institute of Animal Breeding, Kostinbrod, Bulgaria.

NAL Call Number: 49 Z65

Moulting was induced in 12 100 hybrid laying hens 11 months old and blood was taken during the first month after moulting which lasted for 17 days. Egg laying percentage was up to 70, 30 days after moulting. Induced moulting inhibited endogenous cholesterol synthesis and decreased cholesterol concentration of eggs.

Descriptors: egg production, moulting, cholesterol metabolism, hens

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Chotinski D; Aleksandrov M; Milkov V; Andreev M (1990). **Changes in the concentration of thyroxine, triiodothyronine and prolactin in blood plasma during induced moulting in hybrid laying Hisex White hens.** *Zhivotnov"dni Nauki* 27(6): 54-58.

Institute of Poultry Breeding, Kostinbrod, Bulgaria.

NAL Call Number: 49 Z65

Hisex White hens (numbers not given) were subjected to starvation for 4 days, partial water and light restriction (2 h) on days 3 and 4, partial restriction of feed (40 g), water and light (5 h) on days 5-7, and to 60 g feed and 12-h water and light on days 8-21, followed by a gradual weekly increase to a normal level of nutrition and light (16 h). The concentration of thyroxine decreased from 13 nmol/litre on day 0 to 9 nmol/litre on day 3, increased to 18 nmol/litre on day 22, decreased to 10 nmol/litre on day 52, and returned to normal by day 109. Similar

timing of peaks and returns to normal occurred for triiodothyronine and prolactin. 21 ref.
Descriptors: moult, induction, thyroid hormones, blood, prolactin
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Chowdhury VS; Yoshimura Y (2002). **Cell proliferation and apoptosis in the anterior pituitary of chicken during inhibition and resumption of laying.** *General and Comparative Endocrinology* 125(1): 132-141.

Faculty of Applied Biological Science, Hiroshima University, Japan
NAL Call Number: 444.8 G28

White Leghorn laying hens were subjected to inhibition of laying by feed withdrawal to determine whether tissue rejuvenation of the anterior pituitary with cell proliferation and apoptosis occurs during inhibition and resumption of egg-laying. Feeding was resumed on the 4th day after cessation of egg-laying, and bromodeoxyuridine [broxuridine] was intraperitoneally administered (40 mg/kg body mass) an hour before anterior pituitary tissue samples were collected. The sizes of pituitary glandular cells were observed to change during inhibition and resumption of laying. There was no statistically significant correlation between changes in the immunopositive cell population and their sizes within each cell type. However, the sizes of FSH-like cells in anterior pituitary glands collected 10 days after cessation of laying and on the day that laying was resumed, as well as LH-like cells in the glands collected on the day of resumption of laying were larger than those collected around the time that laying was stopped. Thus, the population of gonadotrophs as well as their sizes may be increased around the time that laying is resumed. The results suggest that during inhibition and resumption of laying, the anterior pituitary is likely to be remodeled by proliferation and apoptosis of cells, which occur in association with the changes in the population of hormone-producing cells. Tissue remodeling may result in the rejuvenation of anterior pituitary cells by replacing older cells with new cells and may contribute to the improvement of the function of the anterior pituitary.

Descriptors: anterior pituitary, apoptosis, broxuridine, egg production, gonadotropic cells, hens, laying performance, moulting, pituitary hormones, poultry
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Chowdhury VS; Yoshimura Y (2002). **Changes of lysosomal hydrolase activity in the anterior pituitary of hens during induced molting.** *Japanese Poultry Science* 39(1): 22-26.

Hiroshima Univ., Higashi-hiroshima, Japan
NAL Call Number: 47.8 N57

The goal of this study was to determine whether lysosomal hydrolase activity changes during induced molting in the hen pituitary. White Leghorn aged laying hens were subjected to induced molting by feed withdrawal. Gradual feeding was started on 4th d of egg-laying cessation. The anterior pituitaries were collected from hens of pretreatment, 3 d and 5 d after starvation, 3 d and 10 d after cessation of egg-laying (6 d after resumption of feeding), on day of and 7 d after resumption of egg-laying. They were processed for the detection of acid phosphatase (AcPase) activity by enzyme histochemistry. Sections were then examined under a light microscope with an image analysis computer system. The AcPase activity was

observed in the cellular cytoplasm in both cephalic and caudal lobes of the anterior pituitary in all groups of hens. In the both lobes the positive area increased significantly in the group of 3 d after cessation of egg-laying when compared with pretreatment group. These results suggest that lysosomal enzyme activity in the anterior pituitary of chicken was enhanced a few days after cessation of laying, which may be responsible for the digestion of unusable hormonal granules at this phase. (author abst.)

Cleaver WT; Christensen VL (1981). **Effect of forced molting on plasma glucose and plasma total protein in turkey hens.** *Poultry Science* 60(7): 1597.

Dep. Of Poultry Science, North Carolina State Univ., Raleigh, North Carolina.

NAL Call Number: 47.8 AM33P

Descriptors: large white breed, feed consumption, light effects, seasonal effects, tissue regeneration

Cleaver WT; Christensen VL; Ort JF (1981). **Gross changes in organ weights due to a force molt in turkey hens.** *Poultry Science* 60(7): 1639-1640.

Dep. Poultry Sci., North Carolina State Univ., Raleigh, North Carolina 27650.

NAL Call Number: 47.8 AM33P

Descriptors: large white, ovary, oviduct, liver, heart, spleen, light

Dickerman RW; Wise TH; Bahr JM (1992). **Effect of ovarian regression and molt on plasma concentrations of thymosin beta 4 in domestic hens (*Gallus domesticus*).** *Domestic Animal Endocrinology* 9(4): 297-304.

Department of Physiology and Biophysics, University of Illinois, Urbana

NAL Call Number: QL868 D6

Molt induced by infusion of a gonadotropin-releasing hormone agonist (GnRH-A, ([D-leu6,Pro9]-GnRH –ethylamide]) or feed withdrawal (FW) has been used as a model to study interactions between ovarian activity and thymosin beta 4 during molting in domestic hens. Thirty-three laying hens were divided into three groups: 1, controls, 2, GnRH-A infusion induced molt (GnRH-A), or 3, FW induced molt. All groups had reduced daylength. Blood was sampled weekly and assayed for concentrations of thymosin beta 4 and progesterone (P4). Plasma P4 concentrations were significantly depressed in both treatment groups compared to controls, indicating ovarian regression. Plasma P4 concentrations had returned to control values in the GnRH-A group by 28 d after the start of treatment, while P4 was still depressed in the FW group at day 42 when the experiment ended. Plasma concentrations of thymosin beta 4 were elevated relative to controls from day 7 through day 14 in the GnRH-A group and from day 7 until day 28 in the FW group. It is concluded that plasma concentrations of thymosin beta 4 are elevated during molting in domestic hens, but the elevation is not attributable to depressed P4 concentrations.

Descriptors: *Chickens--physiology--PH; *Feathers--physiology--PH; *Ovary--physiology--PH; *Thymosin--analogs and derivatives--AA ; Feathers--drug effects--DE; Food Deprivation--physiology--PH; Leuprolide --pharmacology--PD; Ovulation--physiology--PH; Progesterone--blood--BL; Thymosin--blood--BL

El-Aroussi MA; El-Tantawy SMT; El-Barkouky EE; El-Said MA; Goher NE (1996). **Effect of forced molting on blood components of laying hens.** *Fayoum Journal of Agricultural Research and Development* 10(2): 44-56.

Descriptors: layer chickens, forced moulting, blood composition, egg production, liver, spleen , animal husbandry methods, animal production, birds, blood, body parts, cardiovascular system, chickens, digestive system, domestic animals, galliformes, livestock, poultry, production

Fontana EA; Ruszler PL; Beane WL; Magar V (1991). **The effect of two feed withdrawal and two corticosterone supplementation programs on overall performance body weight and reproductive organ weights of force-rested layers.** *Poultry Science* 70(SUPPL.1): 159. Poultry Sci. Dep., Virginia Polytechnic Inst., Blacksburg, VA. 24061-0332.

NAL Call Number: 47.8 AM33P

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Garlich J; Brake J; Parkhurst CR; Thaxton JP; Morgan GW (1984). **Physiological profile of caged layers during one production year, molt, and postmolt: egg production, egg shell quality, liver, femur, and blood parameters.** *Poultry Science* 63(2): 339-343.

NAL Call Number: 47.8 AM33P

A longitudinal study of a flock of Single Comb White Leghorn pullets was initiated at 19 weeks of age (preproduction) and continued through a production year, a forced molt, and for 4 months of postmolt production. A representative sample of hens was obtained at 12-week intervals during the first year and at subsequent selected times. Liver lipid, femur weight, femur volume, femur density, egg weight, shell weight, percent shell, milligrams shell/square centimeter of shell surface area, serum calcium, serum phosphorus, and serum alkaline phosphatase were determined. Percent hen-day production peaked at 90% and then declined by .6 to .7% each week during the first production year. After molting, percent hen-day egg production peaked at 80% and declined .9% per week over the subsequent 20 weeks. Egg weight increased continually during the first production year. Shell weight was greatest immediately postmolt; thereafter it declined. Shell thickness was greatest at 31 weeks of age and declined throughout the first year. After molting, the shell thickness of 83-week-old hens was similar to values of hens about 37 weeks of age. Serum calcium and phosphorus of laying hens were influenced by age, feed intake and environmental temperature. The lowest values occurred during hot weather. Liver lipid was lowest in nonlaying hens (17 to 20%) and was approximately 42% of dry weight in laying hens. Femur density was greater in laying than nonlaying hens.

Descriptors: *Chickens--physiology--PH; *Egg Shell--analysis--AN;

*Femur--physiology--PH ; *Liver--metabolism--ME; *Oviposition ; Alkaline

Phosphatase--blood--BL; Calcium--blood--BL; Housing, Animal; Lipids--metabolism--ME; Organ Weight; Phosphorus--blood--BL; Seasons

Garmatina, SM; Novikov BG; Danilova OV (1978). **Function of neurosecretory centres in the hypothalamus of hens with forced moulting.** [Sostoyanie neurosekretornykh yader gipotalamusa]. *Fiziologicheskii Zhurnal*, Kiev, USSR 24(5): 681-686.

NAL Call Number: 444.8 F58

Descriptors: hens, stress, central nervous system, physiology, moulting

Gildersleeve RP (1980). **Physiological rhythms in laying hens and in hens before a forced molt.** *Dissertation Abstracts International*, B 40(12): 5556.

Louisiana State University, USA.

NAL Call Number: Z5055.U49D53

Leghorn layers in the 12th mth of production were placed in 2 sets of environmentally controlled cages, and were exposed to long or short photoperiods in order to maintain egg production or to prepare for moulting resp. Beginning at the onset of moult, 4 hens from each group were killed every 2 h for 2 days. In layers, av. hen-day egg production was 75 plus or minus 5% v 6 in the premoult hens when sampling began. The premoult hens had regressed ovaries, greater body weight losses, and lower hormone levels than layers. A single-peak, daily rhythm of plasma progesterone was seen only in layers. Progesterone level varied with egg location in the oviduct of layers. Episodic progesterone secretion occurred in premoult hens.

Descriptors: moult, induction, body weight, blood, ovaries, size, feathers, hormones, progesterone, glucocorticoids, light, physiology, moulting, egg production

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Gildersleeve RP; Johnson WA; Satterlee DG; Scott TR (1980). **Serum biochemical rhythms in laying hens and in hens before a forced molt.** *Poultry Science* 59(7): 1563.

Poultry Science Dep., Louisiana State Univ., Baton Rouge, LA 70803, USA.

NAL Call Number: 47.8 AM33P

Leghorn hens were housed in 2 climatic chambers under 19 h light and 5 h dark (19L:5D) or 6 h light and 18 h dark (6L:18D) photoperiods to decrease egg production and to prepare for moulting. After 2 weeks, feed was withdrawn from the 6L:18D hens for 2 days to initiate moulting; 3 days later, 4 hens from each group were bled and killed every 2 h during 48 h. Serum total calcium, inorganic phosphorus, alanine aminotransferase and albumin were depressed in the 6L:18D hens, whereas, serum alkaline phosphatase, lactic acid dehydrogenase, aspartate aminotransferase, glucose and cholesterol were increased. Daily rhythms or significant fluctuations over time in serum total Ca, glucose, total protein and albumin were found in both groups. Alanine aminotransferase correlated positively with liver cellular corticosteroid and negatively with plasma corticosterone in 19L:6D hens; aspartate aminotransferase correlated (positively?) with liver cellular corticosteroid in the 6L:18D hens.

Descriptors: blood composition, lighting, hens

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- Gildersleeve RP; Johnson WA; Satterlee DG; Scott RR (1979). **Daily rhythms of plasma progesterone in hens during egg production and before a forced molt.** *Poultry Science* 58(4): 1013-1014.
Poultry Science Dep., Louisiana State Univ., Baton Rouge, LA 70803, USA.
NAL Call Number: 47.8 AM33P
Descriptors: progesterone; blood plasma; hens; diurnal variation
- Gildersleeve RP; Satterlee DG; Johnson WA; Scott TR (1983). **The effects of forced molt treatment on blood biochemicals in hens.** *Poultry Science* 62(5): 755-762.
NAL Call Number: 47.8 AM33P
- Gildersleeve RP; Satterlee DG; Johnson WA; Scott TR (1982). **The effects of forced molt temperature on selected steroids in hens.** *Poultry Science* 61(12): 2362-2369.
NAL Call Number: 47.8 AM33P
- Gregory NG; Wilkins LJ; Kestin SC; Belyavin CG; Alvey DM (1991). **Effect of husbandry system on broken bones and bone strength in hens.** *Veterinary Record* 128(17): 397-399.
Department of Meat Animal Science, University of Bristol.
NAL Call Number: 41.8 V641
The effects of rearing system, forced moulting and three different layer housing systems on broken bones and bone strength, were examined in hens at the end of lay. Weak bones and broken bones were more common in battery hens which had been reared to point of lay on deep litter rather than in cages. The incidence of old breaks was greater in perchery birds (14 per cent) than in tiered terrace birds (5 per cent), and there was also a difference between their incidence in two types of perchery design (17 per cent and 11 per cent). Moulting was associated with a transient decline in bone strength, followed by an increase in strength during the second lay.
Descriptors: *Animal Husbandry; *Bone Density; *Chickens--injuries--IN; *Fractures--veterinary--VE; *Housing, Animal ; Chickens--physiology--PH; Fractures--etiology--ET
- Gulyamov KKh; Komilov DK; Chugunkin DN; Akhmadov T (1977). **Productivity, respiratory gas exchange and heat production in hens force-moulted by different regimes of starvation and water availability in a hot climate. [Produktivnost' I gazoenergeticheskii obmen u kur-nesushek, podvergnutykh lin-ke pri razlichnom rezhime golodaniya I dostupa k vode v usloviyakh zharkogo klimata.]** *Zhivotnovodstva* 9: 139-148.
Tematicheskii Sbornik Nauchnykh Trudov. Tadzhikskii Nauchno-Issledovatel' skii Institut
NAL Call Number: 49 Z6
In the experiment, groups 1-4, each of 1840 line 18 Katman crossbred fowls weighing, on average, 1272-1548 g before the experiment, were force-moulted by withdrawing food for 5, 8, 10 and 12 days resp., after which ad lib. feeding was progressively reintroduced over a 6-day period. Two subgroups of each group were, resp., (a) deprived of water for 3 days at the start of the experiment, and (b) given water ad lib. Egg production traits were recorded for 212 days after starvation. For the 8 subgroups resp. (i.e. 1a, 1b, 2a, 2b, etc.), egg weight

averaged 60.1, 60.1, 60.5, 59.5, 59.8, 60.2, 60.9 and 59.9 g v 58.6 for all hens before the forced moult, shape index 1.38, 1.38, 1.40, 1.38, 1.38, 1.38, 1.40 and 1.38 v 1.36, egg sp. gr. 1.081, 1.078, 1.081, 1.081, 1.079, 1.081, 1.079 and 1.082 v 1.068, percentage of albumen in the egg 52.77, 52.33, 51.58, 52.43, 52.49, 53.01, 52.86 and 52.62 v 58.56, percentage of yolk 36.06, 36.33, 36.90, 37.06, 36.36, 36.72, 35.90 and 36.10 v 31.39, shell thickness 327, 329, 336, 341, 336, 334, 337 and 335 v 309 μ , albumen index 0.086, 0.086, 0.085, 0.086, 0.086, 0.086, 0.084 and 0.085 v 0.086, yolk index 0.431, 0.426, 0.428, 0.423, 0.426, 0.426, 0.422 and 0.429 v 0.418, percentage of hens culled 5.5, 5.7, 5.9, 5.6, 5.3, 5.1, 5.4 and 5.7 v 2.3, number of eggs laid during the experiment 84.08, 87.34, 87.80, 91.27, 83.61, 83.52, 89.82 and 97.27, and weight of food consumed/kg eggs laid 4.14, 3.96, 3.90, 3.76, 4.19, 4.01, 3.84 and 3.47 v 6.16 kg.

Descriptors: moult, induction, laying performance, nutrition, food restriction, water deprivation

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Harimurti S; Yuwanta T; Astuti P; Gunali S (2000). **Hormone profiles and reproductive tract in induced moulted Indonesian quail hens.** *British Poultry Science* 41(Supplement): S64-S65. Faculty of Animal Science, Gadjah Mada University, Yogyakarta, Indonesia
NAL Call Number: 47.8 B77

Hart LE; Pang SF; Nichols CR; Cheng KM (1990). **Plasma melatonin concentrations during force resting of SCWL layers.** *Poultry Science* 69(SUPPL. 1): 60. Dep. Animal Sci., Univ. British Columbia, Vancouver, B.C V6T 2A2, Canada
NAL Call Number: 47.8 AM33P

Descriptors: laying hens, poultry industry, lighting, molting, estradiol, feed withdrawal

Herremans M (1988). **Age and strain differences in plumage renewal during natural and induced moulting in hybrid hens.** *British Poultry Science* 29(4): 825-835. KU Leuven, Landbouwfaculteit, Laboratorium voor Fysiologie der Huisdieren, Heverlee, Belgium
NAL Call Number: 47.8 B77

Descriptors: hens, hybrids, molting, plumage, age, strain differences

Herremans M; Verheyen G; Decuypere E (1988). **Effect of temperature during induced moulting on plumage renewal and subsequent production.** *British Poultry Science* 29(4): 853-861. KU Leuven, Landbouwfaculteit, Laboratorium voor Fysiologie der Huisdieren, Heverlee, Belgium
NAL Call Number: 47.8 B77

Descriptors: hens, temperatures, molting, plumage, poultry feeding, feed conversion

Heryanto B; Yoshimura Y; Tamura T (1997). Cell proliferation in the process of oviductal tissue remodeling during induced molting in hens. *Poultry Science* 76(11): 1580-1586.
NAL Call Number: 47.8 Am33P

Tissue remodeling and calcium binding protein-D28K (CaBP-D28K) dynamics were examined in the oviduct relative to induced molting. The oviductal tissues of premolting, 7, 10, 13, and 16 d after cessation of laying, and postmolting hens were examined. Frequency of proliferating cells and immunoreactive CaBP-D28K molecules were identified by immunocytochemistry for proliferating cell nuclear antigen (PCNA) and Western blot for CaBP-D28K. The relative frequency of PCNA-positive cells in the mucosal epithelium of the magnum, isthmus, and shell gland was low in premolting and 7 d after the cessation of egg laying. In the magnum and isthmus it was markedly increased in 10 and 13 d after cessation, followed by a slight decrease at 16 d after cessation. The frequency in the shell gland was kept high 10, 13, and 16 d after cessation. The frequency of PCNA-positive cells in each segment was decreased when the birds resumed laying. In the stroma of magnum and isthmus where the tubular glands were located, the frequency of PCNA-positive cells was significantly increased 10 d after the cessation of egg laying relative to premolting and 7 d after cessation. In postmolting hens and in hens 16 d after cessation, the frequency was decreased to a same level to that of premolting hen. In the shell gland, the frequency PCNA-positive cells was high at 10, 13, and 16 d, and diminished in postmolting hen. Single immunoprecipitate band for CaBP-D28K was observed in the shell gland of premolting, postmolting, and younger hens, whereas the density of bands was greater in postmolting hens and younger hens than in premolting hens. We suggest that the oviductal tissues are remodeled by replacing the old glandular cells with new ones that are derived from the mucosal epithelium and uninvoluted glandular cells. Such rejuvenation of shell gland tissue may lead the improvement of CaBP-D28K induction.

Descriptors: hens, molting, oviducts, mucosa, shell gland, cell division, immunocytochemistry, antigens, nuclei, calcium binding proteins

Ingram DR; Wilson HR; Mather FB (1982). **The response of the oviduct of white leghorn hens to 2 methods of induced resting.** *Poultry Science* 61(7): 1482-1483.

Department of Poultry Science, University of Florida, Gainesville, Florida 32611.

NAL Call Number: 47.8 AM33P

Descriptors: low sodium diet, low protein diet, photoperiod, shell gland, water and feed restriction

Karapetyan SK; Arutyunyan LA (1977). **Changes in processes of ammonia formation in chicken kidney tissue sections after artificially induced molting.** *Biologicheskii Zhurnal Armenii* 30(1): 3-6.

NAL Call Number: 20 Er4

Klingensmith PM; Hester PY (1985). **Effects of an induced molt and shell quality on the physical dimensions and mineral composition of eggs and intrauterine pH.** *Poultry Science* 64(12): 2368-2376.

NAL Call Number: 47.8 AM33P

Descriptors: hens, molting, soft shelled eggs, shell-less eggs, dimensions, pores, water vapor movement, mineral content, uterus, pH

Meluzzi A; Primiceri G; Giordani R; Farabegoli F (1991). **Forced molt of laying hens. 1: Changes in blood constituents. [Muta forzata di galline ovaiole. 1: Modificazioni dei parametri ematochimici]**. *Proceedings of the 9th National Congress of the Scientific Association for Animal Production [Atti 9. Congresso nazionale Associazione Scientifica di Produzione Animale]*, Istituto Studi, Ricerche e Informazioni Mercato Agricolo: Rome (Italy) , May 1991, v.2: 895-903.

Bologna Univ, Italy, Istituto di Zooculture

Descriptors: layer chickens, forced moulting, blood sampling, blood composition, rations , statistical analysis, oviposition, biological analysis, biological development, birds, blood, chickens, domestic animals, domesticated birds, feeding, galliformes, livestock, moulting, physiological functions, poultry , reproduction, sexual reproduction

Rodin VV (1980). **Sulfur content in the blood and tissues of chickens after forced molting.**

Nauchnye trudy - Stavropol'skii sel'skokhoziaistvennyi institut. 4 (pt.43): 57-60.

Stavropol'skii Institut.

NAL Call Number: 106 ST27

Rodrigues GA; Moraes VMB; Cherici I; Furlan RL; Macari M (1991). **Effects of previous protein intake on rectal temperature, blood glucose, plasma thyroid hormone and minerals by laying hens during a forced molt.** *Ars Veterinaria* 7(2): 78-86.

Depto. de Morfologia e Fisiologia Animal, Fac. de Ciencias Agrarias e Veterinarias, UNESP Rod. Carlos Tonnan, km 5, 14870-000 Jaboticabal, Sao Paulo, Brazil.

NAL Call Number: SF604 A78

The effect of forced moulting induced by starvation on blood glucose, rectal temperature and thyroxine (T4), triiodothyronine (T3) and minerals in plasma was studied in 3 groups of Hy-line W-36 hens, 78 weeks old, previously fed on diets equal in energy with 14, 17 or 20% crude protein. Blood glucose, rectal temperature and minerals decreased during starvation irrespective of previous protein intake. Before moulting plasma T4 was greater in hens given diets with 17 or 20% protein than in those given diets with 14% protein. Starvation decreased T4 and T3 concentrations in hens given diets with 17 or 20% protein. In hens given 14% protein T4 increased and T3 decreased. Results indicate that previous protein intake does not interfere with metabolic changes during forced molt.

Descriptors: thyroid hormones, thyroxine, triiodothyronine, glucose, blood, body temperature, blood chemistry, starvation, moulting, metabolism, protein intake, hens

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Sirotkin AV; Korovin KF (1984). **[Participation of sympathetic-adrenal system catecholamines in regulating the reproduction and molting of the hen] Uchastie katekholaminov simpato-adrenalovoi sistemy v reguliatsii razmnozheniia I lin'ki kury.** *Zhurnal evoliutsionnoi biokhimii I fiziologii (USSR)* 20 (1): 38-42 , ISSN 0044-4529

NAL Call Number: QH345 Z5

Studies have been made of diurnal changes of adrenalin and noradrenalin content of the blood plasma in egg laying and molting hens. In laying hens at night time, as compared to

daily period, the level of both catecholamines decreased, whereas that in molting ones--increased. In laying hens kept under illumination, catecholamine content did not undergo significant diurnal changes. Differences between laying and non-laying hens were absent during the daytime. In laying hens, noradrenalin content of the blood exhibited negative correlation with their egg productivity. Reduction of photoperiod from 14 to 6 h per day resulted in a sharp decrease of egg laying and the development of molting. Under these conditions, artificial increase of adrenalin content of the blood at night time (by means of repetitive injections) prevented the decrease in egg laying. Daily injection of this hormone did not produce this effect. Exogenous adrenalin inhibited molting irrespectively of the time of its injection. Noradrenalin injections did not affect the molting rate and egg laying in hens. The data obtained reveal possible role of natural adrenalin in regulation of egg laying and molting in hens at night time.

Descriptors: Adrenal Glands, Catecholamines, Chickens, Feathers, Reproduction; Sympathetic Nervous System, Circadian Rhythm, Epinephrine, Epinephrine --pharmacology--PD; Feathers--drug effects--DE; Norepinephrine--blood--BL; Norepinephrine--pharmacology--PD; Oviposition--drug effects--DE; Reproduction--drug effects--DE CAS Registry No.: 0 (Catecholamines); 51-41-2 (Norepinephrine); 51-43-4 (Epinephrine)

Stremousov VM (1992). **Morphological transformation in oviduct sections of laying hens under the effect of forced molt.** [Morfologicheskaya transformatsiya v otdelakh yajtsevoda kur-nesushek pod vozdejstviem prinuditel'noj lin'ki]. In *Physiological fundamentals of development, resistance and productivity of animals. [Fiziologicheskie osnovy razvitiya, rezistentnosti i produktivnosti zhivotnykh]*. Kazan' (Russian Federation), p. 106-110

Descriptors in English: layer chickens, forced moulting, ovaries, animal glands, animal morphology, biological development, birds, chickens, domestic animals, domesticated birds, endocrine glands, female genital system, galliformes, genital system, livestock, moulting, poultry, urogenital system

Stremousov VM (1989). **Variation in yolk follicle gradation in laying hens under conditions of artificial moulting.** [Izmenenie gradatsii zheltkovykh follikulov yaichnikov kur-nesushek v usloviyakh prinuditel'noj lin'ki]. In *Biological fundamentals and technological methods for poultry breeding intensification. [Biologicheskii osnovy i tekhnologicheskie metody intensivatsii ptitsevodstva]*. Moscow (USSR), p. 49-53.

Descriptors in English: layer chickens, ovulation, ovarian follicles, forced moulting, animal glands, animal morphology, biological development, biological rhythms, birds, chickens, domestic animals, domesticated birds, endocrine glands, female genital system, galliformes, genital system, livestock, moulting, oestrous cycle, ovaries, physiological functions, poultry, reproduction, sexual reproduction, urogenital system

Suzuki T; Takahashi M; Ishida K (1978). **Histological changes of hen's uropygial glands by forced moulting.** *Journal: Bulletin of Research - Toyama College of Technology* 11: 77-81. Toyama College of Technology, Kosugi, Japan

- Szelenyi Z; Pethes G; Peczely P (1983). **Changes in the plasma concentration of sexual steroids in domestic hens during forced and hormonally-induced molt.** *Acta Veterinaria Hungarica* 31(1/3): 57-63.
Budapest : Akademiai Kiado
NAL Call Number: 41.8 AC83
- Thangavel A; Gomathi VS; Rao RG (1991). **Changes in the plasma proteins, haemoglobin and cholesterol during different periods of forced molting.** *Cheiron* 20(2/3): 54-58.
NAL Call Number: SF604 C56
Descriptors: laying hens, husbandry, blood proteins, cholesterol, hemoglobin, blood chemistry, molting, egg production
- Turkmen G; Mengi A (1994). **Effects of forced moulting on serum lactate dehydrogenase, alkaline phosphatase, calcium, inorganic phosphorus and glucose in caged layers. [Zorlamali tuy degistirmenin yumurta tavuklarinda serum LDH, ALP, Ca, Pi ve glikoz duzeylerine etkileri.]** *Turk Veterinerlik ve Hayvancilik Dergisi* vol. 18 (6): p.321-329.
NAL Call Number: SF1 D57
Descriptors: hens, molting, induction, blood chemistry
- Uyanik F; Mengi A (1993). **Effects of forced moulting on the serum gamma-glutamyltransferase, alanine and aspartate aminotransferases, and albumin and globulin levels in caged layers. [Zorlamali tuy degistirmenin yumurta tavuklarinda serum gama-GT, GOT, GPT, albumin ve globulin duzeylerine etkisi.]** *Veteriner Fakultesi Dergisi (Istanbul)* 19(2): 245-256.
NAL Call Number: SF1 I78
Descriptors: hens, light regime, starvation, molting, blood chemistry, poultry
- Vanmontfort D; Berghman LR; Rombauts L; Verhoeven G; Decuyper E (1994). **Changes of immunoreactive inhibin, follicle-stimulating hormone, luteinizing hormone, and progesterone in plasma after short-term food deprivation and during the ovulatory cycle of the domestic hen.** *General and Comparative Endocrinology* 95(1): 117-124.
Laboratory for Physiology and Immunology of Domestic Animals, Catholic University of Leuven, Heverlee, Belgium.
NAL Call Number: 444.8 G28
The interrelationship between immunoreactive inhibin and follicle-stimulating hormone (FSH) was measured in laying hens after short-term food deprivation and during the ovulatory cycle. Plasma inhibin was estimated by a heterologous radioimmunoassay validated for use in chicken. FSH was measured by a recently developed homologous radioimmunoassay. Ten hens were deprived of food for 10 days (a method to induce artificial moult or to stop egg laying). Blood samples were taken daily via the brachial vein for 10 consecutive days starting on the day of food withdrawal. The data are expressed in relation to the last day of oviposition. Short-term food deprivation, followed by ovarian atrophy, significantly depressed the plasma inhibin and progesterone (P4) concentration. Plasma FSH

concentrations significantly increased, while luteinizing hormone (LH) concentrations slightly but not significantly decreased. In another experiment, 6 hens were induced to moult. The control hens (n = 6) were fed ad libitum. On Day 17, the hens were killed and follicular distribution was studied. The atrophy of the large yolky follicles in restricted hens was associated with a significant increase in the number of white follicles. In a third experiment, serial blood samples were taken from hens (n = 15) at 2-hr intervals for 36 hr via a brachial cannula. Plasma immunoreactive inhibin and FSH concentrations did not vary during the ovulatory cycle. LH and P4 increased simultaneously from basal levels to preovulatory peak values 6 hr before ovulation.

Descriptors: Chickens--physiology--PH; Estrus--physiology--PH; FSH--blood--BL; Food Deprivation--physiology--PH; Inhibin--blood--BL; LH--blood--BL; Progesterone--blood--BL; Oviposition--physiology--PH; Radioimmunoassay

Verheyen G; Decuypere E (1983). **Cessation of laying by induction in the hen. Effect of different methods on some production parameters and on the concentrations of thyroid hormones, prolactin, calcium, phosphorus, sodium and proteins in the blood serum (Force molting).** [Arret de la ponte par induction chez la poule. Effet de differentes methodes sur certains parametres de production et sur les concentrations en hormones thyroïdiennes, en prolactine, en Ca, P, Na et en proteines dans le serum sanguin.] *Revue de l'agriculture* 36(5): 1535-1559.
NAL Call Number: 13 R322

Yamauchi K; Kamisoyama H; Isshiki Y (1997). **Effects of fasting and refeeding on structures of the intestinal villi and epithelial cells in White Leghorn hens.** [Erratum: May 1997, v. 38(2), p. 225-228.] *British Poultry Science* 37(5): 909-921.

Laboratory of Animal Science, Faculty of Agriculture, Kagawa University, Kagawa-ken, Japan.

NAL Call Number: 47.8 B77

The fine structural alterations of villi and epithelial cells in each part of the small intestine were investigated in layer-type hens fasted for 12 h to 20 d or refed for one day after each fasting period. 2. Within the first 2-h-fasting, villi of the duodenum showed a remarkable reduction in height and those of the jejunum revealed a gradual decrease; such a significant reduction of the villus height was not obtained in the ileum. After 36-h-fasting, villus height in each part gradually decreased with days of fasting. 3. All intestinal villus heights increased after only 1-d-refeeding of various kinds of diets following 3-, 10-, or 20-d-fasting. The duodenum especially rapidly recovered even after long-term fasting of 20 d but the ileum showed very slow recovery, suggesting that the ileum seems to be inactive in absorptive function. 4. These variable alterations of villus height in the proximal intestine suggest that the higher intestinal absorptive ability is under the normal feeding, the more rapidly villus height is influenced by nutritional conditions. 5. Cell area and cell mitosis decreased after fasting, the latter showing a marked reduction. However, in spite of a remarkable decrease of cell mitosis in the proximal intestine after fasting, refeeding activated cell renewal and it soon reached control levels, demonstrating that the villus height mainly varied with the numbers of

epithelial cells. 6. In the epithelial cells of the proximal intestine in chickens fasted for 20 d, large lysosomal autophagous vacuoles including mitochondria and dense bodies were observed. These were reduced in size by refeeding for only one day, suggesting that fasting may cause intracellular digestion through lysosomal autophagy. 7. These results lead to the conclusion that long-term fasting for force moulting is possible, that a high protein and high energy diet can be fed immediately after fasting and that a cell undergoing lysosomal autophagy in normal chickens indicates undernutrition.

Descriptors: hens, villi, epithelium, fasting, refeeding, histopathology, cell ultrastructure, animal nutrition

Zigic L; Srajber L; Masic B; Marinkovic V (1970). **The effect of forced molting on the physical properties and inner quality of eggs layed by New Hampshire hens.** *Veterinaria (Sarajevo)* 19(1): 66-71.

NAL Call Number: 41.8 V6494

Descriptors: albumin, yolk, shell

**Records from the
National Agricultural Library
Electronic Catalog**

NAL CALL NO: 100 W52 (1) no.83

Author: Stewart, J. H. (James H.)

Title: Poultry experiments / by J.H. Stewart and Horace Atwood.

Publisher: Morgantown, W.V. : West Virginia University Agricultural Experiment Station, 1902.

Description: p. [443]-465, [3] leaves of plates : ill. ; 22 cm.

Series: Bulletin / West Virginia University Agricultural Experiment Station ; 83

Note: Cover title.

Note: A comparison of beef scraps, ground fresh meat and bone and milk albumen as sources of protein for laying hens -- Ground grain compared with whole grain, and mash fed in the morning and at night, for laying hens -- An experiment to determine the importance of keeping hens warm at night by means of curtains surrounding their perches -- A trial of the VanDreser method of producing an early and uniform moult.

LC Subject: Poultry -- Feeding and feeds.

LC Subject: Poultry -- West Virginia.

NAL CALL NO: Fiche S-70 no.186 (also at 1 Ag84F no.186)

Title: Experiment station work, XXIII compiled from the publications of the agricultural experiment stations: losses in manure, apple pomace for cows, macaroni wheats, rations for laying hens, sterilizing greenhouse soils, early molting of hens, tomatoes under glass, evaporation from incubator eggs, protection of peach buds, the keeping quality of butter, dandelions in lawns, curing cheese in cold storage / prepared in the Office of Experiment Stations. -- [microform] :

Publisher: Washington, D.C. : U.S. Dept. of Agriculture, 1904.

Description: 32 p. : ill. --

Series: Farmers' bulletin / United States Department of Agriculture; no. 186

Note: Includes bibliographical references.

Note: NAL document copy also located in 1 Ag84F no.186

NAL CALL NO: 100 N48C (1) no.258

Author: Rice, James E. (James Edward), 1865-

Title: The molting of fowls / by James E. Rice, Clara Nixon and Clarence A. Rogers.

Publisher: Ithaca, N.Y. : Cornell University, 1908.

Description: p. 20-68 : ill. ; 23 cm.

Series: Bulletin; 258

LC Subject: Molting.

Other Author: Nixon, Clara.

Other Author: Rogers, C. A. (Clarence Arthur), 1882-

Series: Bulletin (Cornell University. Agricultural Experiment Station) ; 258.

NAL CALL NO: Fiche S-70 no.412

Title: Experiment station work, LVIII compiled from the publications of the agricultural experiment stations: fertilizers for pineapples, the forced molting of fowls, wart disease of the potato, a portable panel fence, the typhoid or house fly, pasteurization in butter making, rice and its by-products as feed-stuffs, milling and baking tests with durum wheat / prepared in the Office of Experiment

Stations. -- [microform] :

Publisher: Washington, D.C. : U.S. Dept. of Agriculture, 1910.

Description: 32 p. : ill. --

Series: Farmers' bulletin / United States Department of Agriculture; no. 412

Note: Includes bibliographical references.

Note: NAL document copy also located in 1 Ag84F no.412

NAL CALL NO: 100 M38H (1) no.264

Author: Hays, F. A. (Frank Alfred), 1888- 4n

Title: Duration of annual molt in relation to egg production / by F.A. Hays and Ruby Sanborn.

Publisher: Amherst, Mass. : Massachusetts Agricultural Experiment Station, 1930.

Description: p. [73]-85 ; 23 cm.

Series: Bulletin / Massachusetts Agricultural Experiment Station; no. 264

Note: Bibliography: p. 85.

Note: Cover title.

LC Subject: Eggs -- Production.

LC Subject: Molting.

NAL CALL NO: 100 N48C (1) no.503

Author: Marble, Dean R. (Dean Richmond), 1892-

Title: The molting factor in judging fowls for egg production / Dean R. Marble.

Publisher: Ithaca, N.Y. : Cornell University Agricultural Experiment Station, 1930.

Description: 42 p. : ill. ; 23 cm.

Series: Bulletin ; 503

Note: Bibliography: p. 42.

LC Subject: Molting.

LC Subject: Eggs -- Production.

Series: Bulletin (Cornell University. Agricultural Experiment Station) ; 503.

NAL CALL NO: 100 Ar4 no.143

Gov Doc No.: AES 1.3:B 85/143

Author: Embleton, H. (Harry), 1888- 4n

Title: Poultry feeding experiments / by H. Embleton ; Moulting and housing experiments / by H.B. Hinds.

Publisher: Tucson, Ariz. : University of Arizona, [1933]

Description: p. 80-120, [3] folded leaves : ill. ; 23 cm. Series: Bulletin / Arizona Agricultural Experiment Station ; no. 143

Note: Running title: Poultry feeding, moulting, housing experiments.

Note: "April 1, 1933."

LC Subject: Poultry -- Arizona -- Feeding and feeds.

LC Subject: Poultry -- Arizona -- Feed utilization efficiency.

LC Subject: Poultry -- Housing -- Arizona.

LC Subject: Molting.

NAL CALL NO: 100 AL1S (2) no.64

Author: King, D. F. (Dale Franklin), 1906-

Title: Force-molting of hens and all-night lighting as factors in egg production / by D.F. King and G.A. Trollope.

Publisher: Auburn : Agricultural Experiment Station of the Alabama Polytechnic Institute, 1934.

Description: 7 p. : ill. ; 23 cm.

Series: Circular / Agricultural Experiment Station of the Alabama Polytechnic Institute ; no. 64

Note: Bibliography: p. 7.

Note: Cover title.

Note: "April 1934."

LC Subject: Eggs -- Production.

LC Subject: Chickens, Effect of light on.

LC Subject: Chickens -- Housing -- Lighting.

NAL CALL NO: 100 Or3 no.119

Author: Knowlton, Frank L. (Frank Lester), 1894-1940.

Title: Force-molting of white leghorn hens / [by Frank L. Knowlton].

Publisher: [Corvallis, Or.] : Agricultural Experiment Station, Oregon State Agricultural College, 1936.

Description: 8 p. : ill. ; 24 cm.

Series: Station circular / Agricultural Experiment Station, Oregon State Agricultural College ; 119

Note: Cover title.

LC Subject: Leghorns (Poultry)

LC Subject: Molting.

Other Title: Force molting of white leghorn hens.

Series: Station circular (Oregon State Agricultural College. Agricultural Experiment Station) ; 119.

NAL CALL NO: 100 Ar4 no.177

Gov Doc No.: AES 1.3:B 85/177

Author: Embleton, H. (Harry), 1888- 4n

Title: Poultry feeding experiments / by H. Embleton ; Moulting and housing experiments / by H.B. Hinds.

Publisher: Tucson, Ariz. : University of Arizona, [1941]

Description: p. 331-365 : ill. ; 23 cm.

Series: Bulletin / University of Arizona. College of Agriculture. Agricultural Experiment Station ; no. 177

Series: Bulletin / University of Arizona. College of Agriculture. Agricultural Experiment Station ; no. 143 (1941)

Note: Includes bibliographical references.

Note: Title from cover.

Note: Running title: Poultry feeding and housing experiments.

Note: "Revised Bull. No. 143."

Note: "December, 1941."

LC Subject: Poultry -- Arizona -- Feeding and feeds.
LC Subject: Poultry -- Arizona -- Feed utilization efficiency.
LC Subject: Poultry -- Housing -- Arizona.
LC Subject: Molting.

NAL CALL NO: 41 W32

Author: Watmough, Harry.
Title: French moult.
Publisher: [Shipley, Eng., s.n., 1943]
Description: [10] p.
LC Subject: Molting.

NAL CALL NO: 100 M38H (1) no.429

Author: Hays, F. A. (Frank Alfred), 1888-
Title: Annual molt in Rhode Island Reds / by F.A. Hays and Ruby Sanborn.
Publisher: Amherst, Mass. : Massachusetts State College, 1945.
Description: 24 p. : ill. ; 23 cm.
Series: Bulletin / Massachusetts Agricultural Experiment Station; no. 429
Note: Bibliography: p. 24.
Note: Cover title.
LC Subject: Rhode Island reds.
LC Subject: Molting.

NAL CALL NO: 413 Se4

Author: Seibert, Henri Cleret, 1915-
Title: The relation of photoperiod and temperature to food and water consumption, variations in weight, and molt in birds.
Publisher: Urbana, 1947.
Description: [8] p. 23 cm.
Note: Abstract of thesis--Univ. of Illinois.
Note: Vita.
LC Subject: Birds.
LC Subject: Temperature -- Physiological effect.
LC Subject: Light -- Physiological effect.

NAL CALL NO: 100 F66S (1) no.728

Title: Forced molting of laying hens / H.R. Wilson ... [et al.].
Publisher: Gainesville, Fla. : Agricultural Experiment Stations, Institute of Food and Agricultural Sciences, University of Florida, 1969.
Description: 22 p. ; 23 cm.
Series: Bulletin / University of Florida. Agricultural Experiment Station; no. 728
Note: Bibliography: p. 22.
Note: Cover title.

LC Subject: Molting.
LC Subject: Chickens -- Experiments.
LC Subject: Eggs -- Production.

NAL CALL NO: 100 Or3S no.112

Author: Parlour, James W. (James Wilson)
Title: A study of the economics of force molting in commercial egg production / [James W. Parlour and A.N. Halter].
Publisher: Corvallis : Agricultural Experiment Station, Oregon State University, 1970.
Description: 74 p. ; 23 cm.
Series: Technical bulletin / Oregon State University, Agricultural Experiment Station; 112
Note: Bibliography: p. 66-69.
Note: Cover title.
LC Subject: Eggs -- Production.
LC Subject: Molting.

NAL CALL NO: SF487 M8

Transl Title: Moulting of layers and breeders.
Title: La Mue chez les pondeuses et reproductrices. -
Publisher: Paris : ITAVI, 1977.
Description: 52 leaves ; 30 cm. -
Series: Cahiers techniques de l'ITAVI
Note: Taken from a session held Nov. 17, 1976 at Rennes.
Bibliography: leaves 19-21.
LC Subject: Molting.
LC Subject: Poultry -- Behavior.
Other Author: Institut technique de l'aviculture.
Series: Cahiers techniques de l'ITAVI.

NAL CALL NO: 100 M28S (1) no.755

Author: Gerry, Richard Woodman, 1914-
Title: The effect of forced molting (resting) on the performance of chickens laying brown eggs / R.W. Gerry.
Publisher: Orono, Me. : University of Maine, Life Sciences and Agriculture Experiment Station, 1979.
Description: 19 p. ; 23 cm.
Series: Bulletin / Life Sciences and Agriculture Experiment Station; 755
Note: Bibliography: p. 18-19.
Note: Cover title.
Note: Tables.
LC Subject: Eggs -- Production.
LC Subject: Molting.

NAL CALL NO: 100 H313P no.245

Author: Herrick, R. B. (Raymond B.), 1926- cn

Title: Postmolt performance of four strains of laying hens in open and enclosed housing in Hawaii / R.B. Herrick and E. Ross.

Publisher: [Honolulu] : Hawaii Agricultural Experiment Station, College of Tropical Agriculture and Human Resources, University of Hawaii, [1980]

Description: 12 p. ; 23 cm.

Series: Research report / Hawaii Agricultural Experiment Station, 0073-0998 ; 245

Note: Bibliography: p. 12.

Note: Cover title.

Note: "February 1980."

LC Subject: Eggs -- Production.

LC Subject: Chickens -- Housing.

LC Subject: Molting.

LC Subject: Eggs -- Production -- Economic aspects -- Hawaii.

LC Subject: Chickens -- Hawaii.

NAL CALL NO: 100 H313P no.225

Author: Herrick, R. B. (Raymond B.), 1926- cn

Title: Postmolt performance of two strains of laying hens in open and enclosed housing in Hawaii / R.B. Herrick and E. Ross.

Publisher: Honolulu, Hawaii : Hawaii Institute of Tropical Agriculture and Human Resources, College of Tropical Agriculture and Human Resources, University of Hawaii, [1982]

Description: 15 p. : ill. ; 23 cm.

Series: Research report / Hawaii Institute of Tropical Agriculture and Human Resources, 0073-0998 ; 225.

Note: Bibliography: p. 12.

Note: Cover title.

LC Subject: Eggs -- Production.

LC Subject: Chickens -- Housing.

LC Subject: Molting.

LC Subject: Eggs -- Production -- Economic aspects -- Hawaii.

LC Subject: Chickens -- Hawaii.

NAL CALL NO: 105.8 B644 1990 [no.26]

Author: Kalayci, Ugur Menderes, 1963-

Transl Title: Effects of breeding intensity and methods of molting preparations on the performance of light and medium weight laying hens in the second laying season. -- eng

Title: Auswirkungen der Aufzuchtintensitat und der Methodik der Mausereinleitung auf die Leistungen leichter und mittelschwerer Legehennen in der zweiten Legeperiode / vorgelegt von Ugur Menderes Kalayci.

Publisher: Bonn : [s.l.], 1990.

Description: 137 p. : ill. ; 21 cm.

Note: Includes bibliographical references (p. [103]-121).

Note: Vita.

Note: Thesis (doctoral)--Universitat Bonn, 1990.

NAL CALL NO: 275.29 G29C No.668

Author: Ruzsler, Paul L.

Title: Vacation in the hen house A guide for force molting layers

Publisher: Athens

Description: [6] p.

Series: Georgia. University. Cooperative Extension Service. Circular 668

Series: University of Georgia. Cooperative Extension Service. Circular, 668.

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